

USING MOBILE TECHNOLOGY TO IMPACT FRUIT AND VEGETABLE CONSUMPTION
IN LOW-INCOME YOUTH

By

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ABSTRACT

The benefits of fruits and vegetables (FV) include supplying nutrients and fiber to the diet, reducing risk of disease, and assisting in weight maintenance by increasing satiety and decreasing energy density of the diet. FV intake has been inadequate compared to national recommendations across the population and interventions to increase FV intake in pediatric populations have shown mixed results. This study utilized mobile health technology (mHealth, handheld computers) to deliver an Ecological Momentary Intervention (EMI) incorporating behavior change skills (e.g., goal setting, self-monitoring, problem-solving, feedback, and reward) called Growing up Strong (GuS) to increase FV consumption in low-income, ethnic minority children and adolescent girls. Compared to a paper manual control condition, participants randomized to GuS significantly increased their fruit and combined FV, but not vegetable intake from Baseline to end of intervention (Week 4). Follow-up at Week 12 showed that all treatment gains had been lost. Adherence to the electronic program was high, with participants interacting with the program on 81.1% of days and answering 50.4% of the 6 daily program prompts over the 28 days of the intervention. Results indicate an EMI is acceptable to female youth and can help boost FV intake. Creating fun FV intervention programs that can sustain interest for longevity of use might have a greater impact by preventing immediate return to previous intake levels and reinforcing longer-term lifestyle change. Recommendations are provided for integrating FV intervention into larger multiple health behavior change (MHBC) programs to increase impact on weight management and health outcomes.

Keywords: children, adolescents, weight management, weight prevention, fruit and vegetable intake, health promotion, eHealth, mHealth, handheld computer

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Chapter 1: Introduction and Background

The Problem of Pediatric Obesity and Overweight

Prevalence. For the last few decades the obesity rates in America have been deemed epidemic due to the increase in prevalence within the population. An analysis of national survey data that includes measured heights and weights which span from the early 1960s to today, (the National Health Examination Surveys: NHES I, NHANES I – III; NHANES 1999-2000; 2007-2008; 2009-2010), showed that the prevalence of obesity among adults [Body Mass Index (BMI; calculated as weight in kilograms divided by height in meters squared) > 30] significantly increased from 14.5% to 22.5% between NHANES II (1976-1980) and III (1988-1994) (Flegal, Carroll, Kuczmarski, & Johnson, 1998) and again rose significantly to a 30.5% prevalence rate between NHANES III and 1999-2000 ($p < .001$) (Flegal, Carroll, Ogden, & Johnson, 2002). More recent analyses, which cited adult obesity rates at 35.7% (95% CI, 33.8% – 37.7%) in 2009-2010, have shown leveling trends in overall adult obesity rates; however, there continue to be changes in the distribution of BMI in the population and its severity (Flegal, Carroll, Kit, & Ogden, 2012; Flegal, Carroll, Ogden, & Curtin, 2010; Ogden, Carroll, Kit, & Flegal, 2012b).

A similar story unfolds when examining the obesity and overweight prevalence data in children and adolescents. Rates that had increased significantly in the 1980s and 1990s (Ogden et al., 1997) had started to plateau in the most recent measuring points (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010; Ogden, Carroll, Kit, & Flegal, 2012a). Despite this leveling trend, it is noteworthy that the rates have not shown a trend toward decreasing either (Hedley et al., 2004). The most recent rates, with about 12.5 million children and adolescents being obese in 2009-2010 (Ogden et al., 2012a), are alarming and fuel public health efforts to address

childhood obesity and generate potential solutions, such as helping children and adolescents adopt healthy eating practices, increasing physical education, and creating environments that are supportive of healthy living choices (CDC).

The most recent rates in 2009-2010 for children and adolescents aged 2 – 19 cited 16.9% (95% CI, 15.4% - 18.4%) at or above the 95th percentile of BMI for age (obese), 31.8% (95% CI, 29.8 – 33.7%) at or above the 85th percentile of BMI for age (overweight or obese), and 12.3% (95% CI, 11.1%-13.5%) at or above the 97th percentile of BMI for age (extremely obese) (Ogden et al., 2012a). According to this analysis of 2009-2010 data, the pediatric obesity rates were greater in adolescents, compared to preschool age children, and showed a significant increasing trend in increasing age categories overall and for female children (Figure 1). Furthermore, when combining all survey years together from 1999 – 2010, preschool children had lower odds of being obese compared to adolescents aged 12 – 19 for females (OR, 0.62; 95% CI, 0.51-0.74) and males (OR, 0.58; 95% CI, 0.48-0.70) (Ogden et al., 2012a).

Although overall obesity rates have shown a recent trend of starting to stabilize in both adult and pediatric populations, the severity of obesity (i.e., those falling in higher ranges) and the BMI distribution in the population continue to change, which causes concern for those disproportionately affected in certain high-risk groups. The sustained rates of childhood obesity are especially concerning because of the impact of obesity on acute and chronic health, as well as the tracking of obesity into adulthood (A. S. Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008; L. Y. Wang, Chyen, Lee, & Lowry, 2008). Public health efforts are still targeting a reduction in childhood obesity prevalence, but the reduction goal has shifted from a very ambitious 5% overall prevalence in Healthy People 2010, to a more realistic reduction goal of

14.6% overall prevalence in Healthy People 2020. In order to meet these goals, there is a need for increased prevention efforts in early childhood (Ogden et al., 1997) as well as more intense interventions for all age groups and families. These efforts are especially important in high-risk populations, such as adolescents and ethnic minorities, in order to decrease the overall prevalence and impact of pediatric obesity (Y. C. Wang, Orleans, & Gortmaker, 2012).

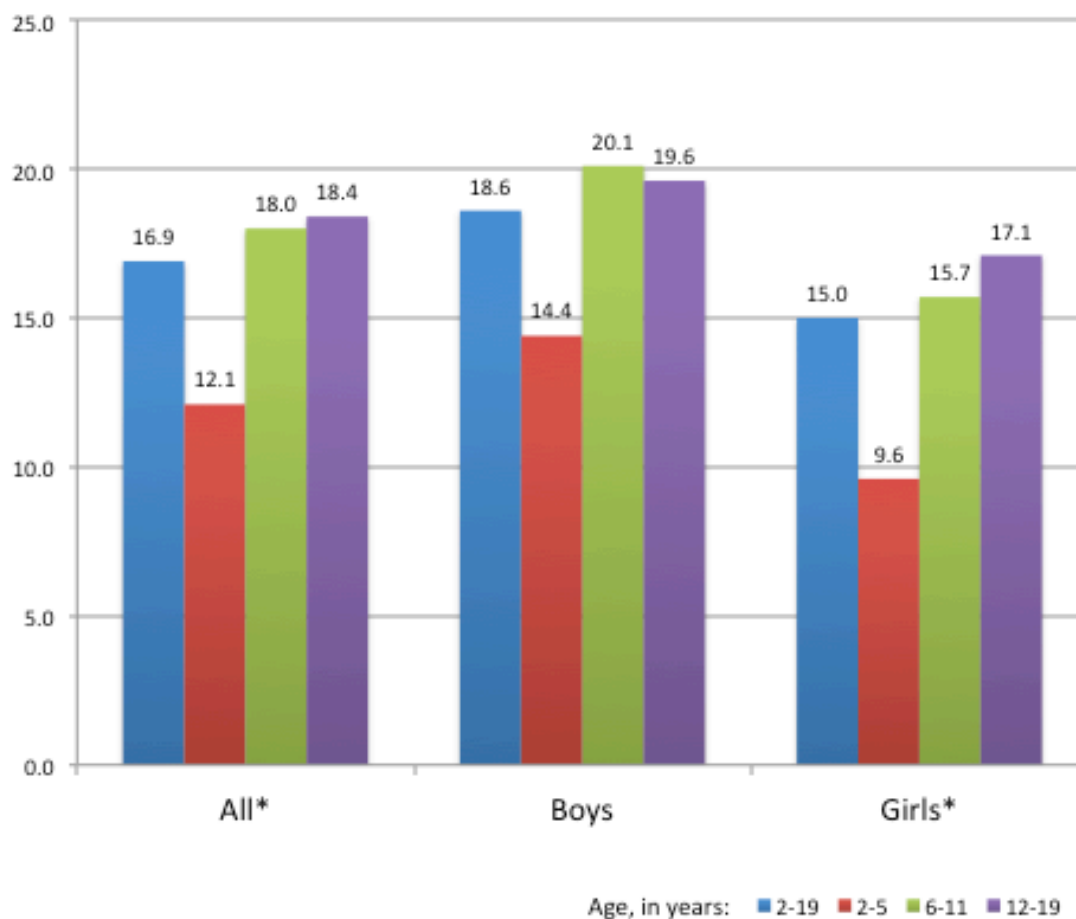


Figure 1. Prevalence of obesity among children and adolescents in the United States, 2009-2010.
*Significantly increasing linear trend by age ($p < 0.005$); SOURCE: CDC/NCHS, National Health and Nutrition Examination Survey 2009-2010.

Impact. Obesity is one of the leading causes of preventable death and disability in the United States, causing an estimated 1 in 10 deaths (Danaei et al., 2009; Mokdad, Marks, Stroup, & Gerberding, 2005). Obesity is associated with an increased prevalence of several notable

health conditions, including the top three causes of death (i.e., cardiovascular disease, cancer and cerebrovascular events), as well as adult and pediatric Type-II diabetes, hypertension, pulmonary disorders, renal disease, non-alcoholic fatty liver disease with cirrhosis, sleep apnea, musculoskeletal disorders and mobility limitations (Abrams & Levitt Katz, 2011; Andreyeva, Sturm, & Ringel, 2004; Eissa & Gunner, 2004; Hall et al., 2003; Hedley et al., 2004; Houston et al., 2009; Li, Bowerman, & Heber, 2005; T. Nguyen & Lau, 2012; Sturm, Ringel, & Andreyeva, 2004; Y. C. Wang, McPherson, Marsh, Gortmaker, & Brown, 2011). There is evidence that the duration of obesity is related with risk of mortality (Abdullah et al., 2011; Maffeis & Tato, 2001), which has dire implications for those with early-onset obesity.

The medical condition linked to obesity which has shown the most dramatic increase in rates is Type II diabetes (ADA, 2000). According to the Centers for Disease Control morbidity and mortality data, diabetes is among the top 10 leading causes of death in the United States (CDC, 2012a), with other long-term complications including renal failure, nerve and retinal damage, and cardiovascular disease. In 2008, diabetes was the 8th leading cause of death for 15-24 year olds, with 70,553 deaths over all age categories. Type II diabetes accounts for more than 90% of all diabetes cases and is more common in adults than children; however, the prevalence in children, has been on the rise, especially in certain high-risk groups (e.g., Native American and Hispanic children) (Anderson & Whitaker, 2009; Dabelea et al., 1998). Although the prevalence of diabetes and mortality from this disease increase with age, complications can occur at earlier ages. With children developing diabetes at younger ages than in the past, these complications will likely occur at earlier ages as well, especially in individuals with diabetes that is poorly managed. Targeting obesity and certain behavioral risk factors (e.g., sedentary

lifestyle, increased fat consumption and other dietary behaviors) are key in curbing these increases in diabetes prevalence (Cheng, 2005; Madden, Loeb, & Smith, 2008; Stern, 1991; Venditti & Kramer, 2012).

Obesity does not just affect individuals; it impacts society at large. Conditions related to obesity account for a significant percentage of overall health care costs in this nation (Li et al., 2005; Y. C. Wang et al., 2011). Furthermore, obesity, impacts both direct (medical) and indirect (lost work productivity) costs (John, 2010; Wolf & Colditz, 1998). Even before medical complications arise, obesity may still be impacting other important, but less quantifiable factors, such as children's self-esteem and socialization practices. Obese children may feel isolated and rejected, which can impact their psychosocial development (De Niet & Naiman, 2011; French, Story, & Perry, 1995). The impact of obesity and overweight is significant, and children are susceptible to both acute and long-term ramifications of this disease.

Children at high-risk. Certain racial and ethnic groups are disproportionately affected by overweight and obesity (Winkleby, Robinson, Sundquist, & Kraemer, 1999). National survey data (NHANES) from 1999-2002 showed that for girls aged 6 – 19, non-Hispanic Caucasian girls had significantly lower obesity prevalence rates than non-Hispanic African American and Mexican American girls. In the same age category, Mexican American boys had a significantly higher prevalence of overweight than non-Hispanic Caucasian and African American boys (Hedley et al., 2004). Significant differences by ethnicity or race were again found in the NHANES data for 2007-2008. Compared to non-Hispanic Caucasian girls, non-Hispanic African American girls were significantly more likely to have high BMI at all 3 cut-points (97th percentile, OR, 1.77; 95% CI, 1.09-2.88; 95th percentile, OR, 1.70; 95% CI, 1.07-2.71; and 85th

percentile, OR, 1.58; 95% CI, 1.13- 2.20; Ogden et al., 2010). Boys were also impacted.

Compared with non-Hispanic Caucasian boys, Hispanic boys were significantly more likely to have a high BMI at all 3 cut-points (97th percentile, OR, 1.72; 95% CI, 1.13-2.63; 95th percentile, OR, 1.80; 95% CI, 1.26-2.58; and 85th percentile, OR, 1.65; 95% CI, 1.14- 2.38). Looking at NHANES data over the last 12 reported years (1999-2010) for children and adolescents aged 2 - 19, non-Hispanic black males (OR, 1.27; 95% CI, 1.09-1.48) and females (OR, 1.99; 95% CI, 1.69- 2.35) and Mexican American males (OR, 1.81; 95% CI, 1.56-2.09) and females (OR, 1.47; 95% CI, 1.23-1.76) were more likely to be obese than their non-Hispanic Caucasian male and female counterparts (Ogden et al., 2012a).

These disparities are evidenced in the adult population, as well. Recent analyses show that although overall obesity rates did not increase over the past decade, significant increases occurred for non-Hispanic black women and Mexican American women (Flegal et al., 2012). Ethnicity has also been shown to predict adult obesity, along with baseline (childhood) BMI, in longitudinal data, with African American females being 2.0 (95% CI, 1.3-3.2) times more likely than Caucasian females to be obese adults (L. Y. Wang et al., 2008). Because of the tracking of obesity into adulthood, disparities that exist in childhood are likely magnified in the adult years. For example, the obesity prevalence in non-Hispanic Caucasian women was 32.2% in 2009-2010, compared to 58.5% in non-Hispanic African American women and 44.9% in Mexican American women (Flegal et al., 2012). Both pediatric and adult data indicate special intervention and prevention programs targeting ethnic minority children are needed.

Health disparities exist for obesity and obesity-related diseases (e.g., heart diseases, diabetes) based on socioeconomic status, in addition to race and ethnicity (Bethell, Simpson,

Stumbo, Carle, & Gombojav, 2010; G. K. Singh, Kogan, Van Dyck, & Siahpush, 2008; Winkleby et al., 1999). Together, these factors impact health due to discrimination, limited resources (e.g., lack of health care), and other health behaviors, such as low adherence to medical treatments or to dietary and physical activity recommendations (Braveman, Cubbin, Egerter, Williams, & Pamuk, 2010; Hughes & Ng, 2003; Kirkpatrick, Dodd, Reedy, & Krebs-Smith, 2012; Sanders-Phillips, Settles-Reaves, Walker, & Brownlow, 2009; Williams, 1999). Health disparities among children are evidenced through higher rates of mortality and disability and greater odds of being in poor health for ethnic minority compared to non-minority youth and lower compared to higher socioeconomic groups (Flores, Olson, & Tomany-Korman, 2005; Lantz et al., 1998; Mehta, Lee, & Ylitalo, 2012; Newacheck & Starfield, 1988; Wise, Kotelchuck, Wilson, & Mills, 1985). There is evidence that disparities are growing, especially related to obesity outcomes. For example, a study examining the changes in obesity prevalence from 2003 - 2007 using data from the National Survey of Children's Health showed that obesity prevalence was greatest and was increasing most rapidly in low-education, low-income, and higher unemployment households (G. K. Singh, Siahpush, & Kogan, 2010b). This again highlights the need to target intervention and prevention programs for low SES, ethnic minority children.

Ethnic minorities are at a greater risk of obesity and its health-related complications as evidenced in pediatric and adult prevalence data. Furthermore, lower SES groups, which are disproportionately comprised of ethnic minorities, have more barriers to receiving adequate healthcare and to engaging in healthy lifestyle behaviors, such as environments that do not promote healthy eating or physical activity (Sallis et al., 2011). Ways to increase access and use

of resources in poor and underserved populations are important considerations when developing obesity prevention and intervention programs for high-risk individuals.

Etiology. Although the cause of obesity is a complex intersection of social-environmental and individual-behavioral and biological factors, obesity is a condition of excess weight, in the primary form of extra lipid storage, resulting from a chronic imbalance in energy where energy intake exceeds energy expenditure (Redinger, 2009).

Behavioral factors. Lifestyle and behavioral factors (i.e., poor nutrition and inactivity) primarily contribute to overweight and obesity. They are also risk factors for the leading causes of death in the United States: heart disease, cancer, and stroke (Berkey, Rockett, Field, Gillman, & Colditz, 2004; Hung et al., 2004; Ludwig, Peterson, & Gortmaker, 2001; Lytle, 2002).

Fruit and vegetable intake. One diet-based contributor to pediatric obesity and overweight is inadequate fruit and vegetable (FV) consumption (Blanchette & Brug, 2005; Glanz & Hoelscher, 2004; Klepp et al., 2005; Neumark-Sztainer, Story, Resnick, & Blum, 1996; Perez-Rodrigo et al., 2005; Striegel-Moore et al., 2006; Videon & Manning, 2003; Yngve et al., 2005). Nationally-sampled data from the NHANES 2003-2004 highlights these inadequacies: only 6.2% of adolescents (aged 12 – 18) met fruit intake guidelines, with intake primarily consisting of fruit juices, and only 5.8% met vegetable guidelines, with intake primarily consisting of white potatoes (Kimmons, Gillespie, Seymour, Serdula, & Blanck, 2009). Excluding fried potato intake, the percentage meeting vegetable intake guidelines dropped to 2.2%. National data from the 2011 Youth Risk Behavior Surveillance System (YRBSS) examining FV intake among 9th – 12th graders highlight that this inadequate FV consumption continues and that there are some differences based on ethnicity (Table 1), with African American adolescents being more likely to

report that they did not consume any FV in the last 7 days than their white counterparts (CDC, 2012c). A longitudinal study by Striegel-Moore et al. (2006) followed African American and white, non-Hispanic, adolescent girls (age 9-10) for 10 years and found the same trend, with only a small number of girls meeting FV intake recommendations at each assessment. Over the 10-year period, the average fruit intake was significantly greater for white (range, 1.18-1.50 servings per day) compared to African American girls (range, 0.98-1.20 servings per day). Average daily vegetable intake did not differ between African American (range, 1.93 – 2.51 servings per day) and white girls (range, 1.69 – 2.35 servings per day). Both groups of girls had inadequate consumption of nutrient-rich vegetables (e.g., orange or leafy greens; range 0.13 – 0.25 servings per day). Data with younger children has shown the same patterns of inadequate FV consumption (Krebs-Smith et al., 1996; Lorson, Melgar-Quinonez, & Taylor, 2009; Mannino, Lee, Mitchell, Smiciklas-Wright, & Birch, 2004; Prelip, Kinsler, Thai, Erausquin, & Slusser, 2012), with children in both 6 – 11 and 12 – 17 age categories showing deficits in consumption of FV, especially dark green and orange vegetables and whole fruit (USDA, 2009).

Table 1
Fruit and Vegetable Intake 9th-12th graders, YRBSS 2011 Data

Survey Data	Overall (%)	White (%)	Black/African American (%)	Hispanic (%)	Racial/Ethnic Group Differences (p<.05)
Vegetables 1+ times per day	62.3	65.7	54.3	56.4	White>Black or Hispanic
Vegetables 2+ times per day	28.3	29.1	24.9	26.8	White>Black
Vegetables 3+ times per day	15.3	14.4	15.8	16.0	Males>Females in some racial/ethnic categories
No vegetables in past 7 days	5.7	4.0	9.9	8.2	Black and Hispanic>White
Fruit 1+ times per day	64.0	64.2	63.6	64.7	Males>Females in some racial/ethnic categories
Fruit 2+ times per day	34.0	32.8	37.2	35.6	Black>White
Fruit 3+ times per day	22.4	20.0	27.9	24.8	Black>White or Hispanic
No fruit in past 7 days	4.8	6.5	4.5	4.5	Black>White or Hispanic

Note: Source is Youth Risk Behavior Surveillance System (YRBSS) 2011. Fruit intake included 100% fruit juice; vegetable intake excluded French fries, fried potatoes, or potato chips. All questions inquired about intake during the 7 days before the survey. Only the largest three demographic categories are presented separately here. Overall category includes all categories, including ones not presented separately. For full demographic information, consult Youth Online (<http://apps.nccd.cdc.gov/youthonline/App/Default.aspx>)

Inadequate FV consumption is partly related to obesity and overweight because children with low consumption levels likely replace fruit and vegetables, which have less calories per serving compared to other food categories, with foods and beverages with higher caloric density, including foods that are high in dietary fats and sugars. For example, there is evidence that children and adolescents often have increased intake of sugar in their snacking (Dwyer et al., 2001) and fast-food consumption in adolescents has been linked with decreased consumption of FV (Bowman, Gortmaker, Ebbeling, Pereira, & Ludwig, 2004; Paeratakul, Ferdinand, Champagne, Ryan, & Bray, 2003; Sebastian, Wilkinson Enns, & Goldman, 2009). Modifying energy density in the diet by increasing FV consumption is a promising strategy for decreasing total daily caloric intake, with small changes (-10 kcals/gram) translating into caloric reductions of 80 calories or more per day (Rolls, Drewnowski, & Ledikwe, 2005). Furthermore, FV consumption contributes to fiber intake, which is linked to satiety and is recommended for weight management in children and adults (Lyon & Kacinik, 2012).

Researchers have shown that the energy gap that is related to obesity in children (more energy consumed than expended) can be addressed by making very small and consistent changes in diet and/or physical activity. A daily calorie reduction of less than 70 calories per day could help this country reach *Healthy People 2020* goals for childhood obesity (Y. C. Wang et al., 2012). Regarding FV intake, a modest goal would be to replace one higher-calorie snack with a lower-calorie fruit or vegetable option each day. For example, replacing a bag of chips (150 calories) with a medium-sized apple (72 calories) would result in a reduction of more than 70 calories, which would address the energy gap.

Sugar-sweetened beverages and fast food. Another dietary contributor to energy imbalance in youth is the increased consumption of sugar-sweetened beverages and high-fat fast foods that has been evidenced over the past several decades, with both being associated with increased total daily energy intake and decreased essential nutrient intake (Bowman et al., 2004; French, Lin, & Guthrie, 2003; Lasater, Piernas, & Popkin, 2011; Paeratakul et al., 2003; Y. C. Wang, Bleich, & Gortmaker, 2008). Several studies have shown that consumption of sugar-sweetened beverages is related to adolescent weight gain (Berkey et al., 2004; Ludwig et al., 2001; Malik, Schulze, & Hu, 2006). Similar evidence points to the link between consumption of food away from home and adiposity, with fast food consumption having been shown to predict increase in BMI in adolescent longitudinal data (Niemeier, Raynor, Lloyd-Richardson, Rogers, & Wing, 2006; Rosenheck, 2008; O. M. Thompson et al., 2004).

With these three primary dietary behaviors contributing to the obesity epidemic in children: inadequate fruit and vegetable consumption, increased fat intake, and increased sugar consumption, particularly in the form of sweetened beverages, there are several prime dietary behaviors to target in order to close the energy gap (Barlow, 2007). Although targeting one of these behaviors could make a difference for many children, especially for prevention, targeting multiple behaviors may be required for other children who are already overweight or obese. Furthermore, Y.C Wang et al. (2012) suggest that for high-risk groups that are disproportionately affected by the pediatric obesity epidemic (i.e., adolescents and ethnic minority youth), larger daily reductions in energy intake will be needed, which indicates the need to target multiple behaviors.

Avenues to educate children and teens and to help them monitor their eating habits and to increase their motivation toward developing healthier eating behaviors are essential to bringing their diets closer to national recommendations, such as consuming at least 5 servings, or 2 ½ cups, of fruit and vegetables each day; consuming adequate fiber; keeping contribution of dietary fat to no more than 25-35% of daily calories; and limiting added sugars in foods and beverages (Gidding et al., 2006; USDA, 2012). Adhering to these recommendations is important, not only because it protects against obesity and overweight, but also because it ensures more of children's diet contains important nutrients, such as fiber, protein, and essential vitamins and minerals that are necessary for better health and to reduce the risk of chronic disease (Amre et al., 2007; Bortsov et al., 2011; D'Souza et al., 2008; McNaughton, Ball, Mishra, & Crawford, 2008; T. Nicklas & Johnson, 2004; Papandreou, Karabouta, & Rousso, 2012; Shang et al., 2012; Van Duyn & Pivonka, 2000).

Energy expenditure. Energy expenditure, which includes basal metabolic rate, diet induced thermogenesis, and physical activity, is on the other side of the energy balance equation (Donahoo, Levine, & Melanson, 2004). Decreased physical activity impacts adiposity through several means. Foremost, sedentary behavior decreases overall daily energy intake requirements in children by competing with more active behaviors or activities. Screen-time (e.g., television watching, video-gaming and computer-use), which has been shown to increase odds of being overweight in children and adolescents (Sisson, Broyles, Baker, & Katzmarzyk, 2010; Ullrich-French, Power, Daratha, Bindler, & Steele, 2010) and to increase during the adolescent years (Nelson, Neumark-Stzainer, Hannan, Sirard, & Story, 2006), may involve a multilayered contribution. Studies that have focused on television viewing have shown that

advertisements may impact food preference in children (W. H. Dietz, Jr. & Gortmaker, 1985; IOM, 2006). Many studies have established a link between increased television viewing and unhealthy snacking behaviors, including decreased fruit and vegetable and dairy consumption and increased consumption of fast food and calorie-dense food (Barr-Anderson, van den Berg, Neumark-Sztainer, & Story, 2008; Blass et al., 2006; Boynton-Jarrett et al., 2003; Matheson, Killen, Wang, Varady, & Robinson, 2004; Miller, Taveras, Rifas-Shiman, & Gillman, 2008; Skatrud-Mickelson, Adachi-Mejia, & Sutherland, 2011; Taveras et al., 2006). Decreased physical activity also impacts adiposity through metabolic channels, with increased exercise and muscle promoting greater fat oxidation, which is protective of adiposity.

Genetics. There are multiple ways that genetics impact overweight and obesity (Crocker & Yanovski, 2011), and heritability of both BMI and waist circumference have been found in twin studies (Wardle, Carnell, Haworth, & Plomin, 2008). Several studies have demonstrated that there is a biological underpinning or risk factors to developing obesity (Barness, Opitz, & Gilbert-Barness, 2007; Bouchard & Perusse, 1993; Farooqi, 2005, 2006; Guilleume & Bjorntorp, 1996; Perusse & Bouchard, 2000; Zahid, 2003). Genetics most likely impacts adiposity through a gene-environment interaction (Maffeis, 1999, 2000); however, a full description is beyond the scope of the current study.

Environmental factors. America's political and cultural climates have contributed to the current obesity epidemic. Iowa's senator Tom Harkin has been quoted saying: "We don't have a health-care system in America; we have a 'sick care' system...we must recreate America as a 'wellness society' focused on fitness, good nutrition and disease prevention..." (Ornish, 2008).

Furthermore, the culture of excess food, increased value placed on convenience foods, and increased sedentary lifestyles have greatly impacted the development of obesity.

There have been numerous studies that have described the built environment and how it impacts physical activity and diet, as well as overweight/obesity and related diseases (Booth, Pinkston, & Poston, 2005; F. Khan, 2011; Miranda, Edwards, Anthopolos, Dolinsky, & Kemper, 2012; Saelens et al., 2012; Sallis, Floyd, Rodriguez, & Saelens, 2012; Salois, 2012a, 2012b; G. K. Singh, Siahpush, & Kogan, 2010a). Other studies have addressed how income disparities relate to built environments (Sallis et al., 2011), how these environments may moderate obesity treatment effects (Epstein et al., 2012) and how modifications at multiple levels could create environments that are conducive to more active and healthy lifestyles (F. Khan, 2011; Sallis & Glanz, 2006, 2009; Taylor et al., 2007)

Regarding fruit and vegetable consumption, fruit and vegetable availability in urban communities have been shown not only to impact consumption of fruit and vegetables, but also obesity rates, with obesity odds increasing and odds of consuming fruit and vegetables five or more times per day decreasing as distance to supermarkets increase in metropolitan areas (Michimi & Wimberly, 2010). Disparities exist in the availability of fruits and vegetables, with predominantly Caucasian neighborhoods in urban areas being more likely to have supermarkets, with fresh and organic options available, compared to racially heterogeneous and predominantly African American neighborhoods (Morland & Filomena, 2007). According to a review of studies of the consumer food environment conducted over the past decade, most (but not all) have shown that these disparities do exist in at least some contexts and some urban centers (Gustafson, Hankins, & Jilcott, 2012).

Environments are also impacted at the family level. For example, parent and child adiposity and fat intake are related, and parents, especially of younger children, are responsible for the food availability in the home (V. T. Nguyen, Larson, Johnson, & Goran, 1996). According to a review of 60 studies, the home environment, including home availability, parental modeling and intake, and parental encouragement, have been shown to be positively associated with children and adolescent's fruit and vegetable consumption (N. Pearson, Biddle, & Gorely, 2009). Perceived modeling seems to be one of the most consistent correlates to children and adolescent eating behavior (McClain, Chappuis, Nguyen-Rodriguez, Yaroch, & Spruijt-Metz, 2009).

Obesity and Overweight Prevention

As previously discussed, obesity is best explained by an interaction of individual (lifestyle behaviors, genetic) and environmental (cultural, political, familial) factors. Thus, preventing and combating pediatric obesity requires attention at the individual, family, community, and legislative levels. This study focuses primarily on the individual (behavioral) level, but recognizes that this is only one component in addressing the overall problem of pediatric obesity and overweight.

To make any substantial changes in the current rates of overweight and obesity, Lee and Lee (2011) conducted an analysis involving the White House Task Force's 2010 pediatric obesity goals and concluded that treatment is a necessary complement to prevention efforts. However, once individuals are overweight or obese, especially in the higher cut-points of BMI, treatments to reverse the disorder can be challenging, with weight regain a common occurrence following weight loss for adults and adolescents (Phelan & Wing, 2005; Rolland-Cachera et al., 2004;

Wing & Phelan, 2005). Furthermore, several facts provide evidence that obesity is a *chronic* disease, such as its course and relapsing nature. Because of this, sustained efforts are necessary and the maintenance of treatment gains requires persistent lifestyle change (Seagle, Strain, Makris, & Reeves, 2009). In fact, the behaviors associated with weight maintenance are identical to those that lead to successful weight loss (Champagne et al., 2011; Del Corral, Bryan, Garvey, Gower, & Hunter, 2011; Wing & Phelan, 2005). Because of the effort and cost required to treat obesity, in addition to the limited success of available treatment programs for adults and children (McGovern et al., 2008), prevention of obesity in childhood is preferred (ADA, 2006; Barlow, 2007; Ells et al., 2005), especially before health ramifications from the disease are experienced.

Although metabolic issues and other individual factors can influence the development of overweight and obesity, excess lipid storage is still a somewhat straightforward imbalance of energy and can be impacted by either increasing energy expenditure or decreasing energy intake (Redinger, 2009), with the cornerstone intervention components being behaviorally-based – that is, reducing total caloric intake, increasing physical activity, and utilizing behavioral change strategies (i.e., cognitive-behavioral techniques, such as self-monitoring and goal-setting) (Berkel, Poston, Reeves, & Foreyt, 2005; Butryn, Webb, & Wadden, 2011; Dolinsky, Armstrong, & Kinra, 2012; Foster, Makris, & Bailer, 2005; Patrick et al., 2006; Patrick et al., 2001; Robinson, 1999a; Wadden, Butryn, & Wilson, 2007; Whitlock, O'Conner, Williams, Beil, & Lutz, 2010). Lifestyle change interventions, which include reducing caloric intake, increasing physical activity and utilizing behavior change skills, have shown the ability to support a 10% initial weight loss (Butryn et al., 2011). In addition, these types of interventions show promising

results for weight loss, weight management and improving dietary behaviors in youth (Kitzmann et al., 2010).

Behavioral-based pediatric obesity prevention programs target one or more primary behaviors to curb weight gain as growth occurs. Primary behaviors recommended to address *prevention* of pediatric overweight and obesity that have supporting evidence include: consuming 5 or more fruit and vegetable servings per day (Buijsse et al., 2009; Epstein et al., 2001; Rolls, Ello-Martin, & Tohill, 2004; Tohill, Seymour, Serdula, Kettel-Khan, & Rolls, 2004), minimizing intake of sugar-sweetened beverages (Harrington, 2008; James & Kerr, 2005; James, Thomas, Cavan, & Kerr, 2004), limiting screen time to ≤ 2 hours per day (Ariza, Greenberg, & Unger, 2004; Boutelle, Libbey, Neumark-Sztainer, & Story, 2009; Epstein, Paluch, Gordy, & Dorn, 2000; Patrick et al., 2006; Robinson, 1999b; Robinson et al., 2010), eating breakfast daily, limiting fast food consumption or eating away from home, encouraging family meals, and limiting portion sizes (Barlow, 2007; Davis et al., 2007). Additional recommendations, which lack consistent evidence, include being physically active at least 1 hour per day, eating a balanced diet rich in fiber and calcium and limiting consumption of energy-dense foods (Barlow, 2007). Because obesity prevention is best addressed in youth and increasing fruit and vegetable consumption is one of the top behaviors recommended by experts to prevent pediatric obesity, based on supporting evidence, the present study sought to explore ways to impact this behavior in children and adolescents.

Creating an Intervention to Increase Fruit and Vegetable Consumption

Fruit and vegetable interventions. Increasing fruit and vegetable (FV) intake can help decrease energy density in the diet and increase dietary fiber, as well as reduce overall energy

intake, which are all important components for maintaining a healthy weight (Davis et al., 2007; Epstein, Myers, Raynor, & Saelens, 1998; Force, 1998; Rolls et al., 2005; Spear et al., 2007). In order to make the biggest impact, decreasing overall daily caloric intake must be achieved. This is why programs stress the importance of substituting whole FV for high-sugar and high-fat foods, such as in the CDC publication “How to use fruits and vegetables to manage your weight” (CDC, 2011). Substituting 100% juice for other sugary beverages can also be an effective strategy to increase nutrient intake and decrease percent fat and sugar intake (O’Neil, Nicklas, & Kleinman, 2010; O’Neil, Nicklas, Zanovec, & Fulgoni, 2011; O’Neil, Nicklas, Zanovec, Kleinman, & Fulgoni, 2012). Increasing FV intake among both adults and children has been identified in Healthy People 2020 as a core objective. However, it may be more important to target efforts at children and adolescents because it is during these years that the percentage who meet recommendations falls, and these dietary patterns track into adulthood (Lien, Lytle, & Klepp, 2001).

Increasing FV intake is a core component of many behavioral-based obesity prevention or treatment programs and the focus of general health promotion programs, including Epstein’s traffic light diet; *5 A Day for Better Health* programs (e.g., *Gimme 5*); *PACE+*; *5-a-day Boy Scout Achievement Badge Program*; *Fun, Food and Fitness Program*; *GEMS*; and *Healthy Eating, Healthy Weights for Healthy Kids* (Baranowski et al., 2002; Baranowski et al., 2000; Epstein & Squires, 1988; Havas et al., 1995; Patrick et al., 2006; Patrick et al., 2001; Shield & Mullen, 2011; Story et al., 2003; D. Thompson et al., 2009; Valoski & Epstein, 1990).

According to a recent systematic review of pediatric obesity programs, Epstein’s traffic light diet is a the most common dietary component of programs (Staniford, Breckon, &

Copeland, 2012). A big focus of the diet is consuming “green” foods, which consists of fruit and vegetables, whenever hungry and as a large portion of meals (Epstein & Squires, 1988). The diet instructs participants to minimize “red” calorie-dense foods and to consume recommended amounts, albeit using portion control, of “yellow” foods (i.e., grains and low-fat dairy and proteins).

A review of behavioral-based FV randomized controlled trials with 40 or more participants from 1975 to 1999 was conducted by Ammerman, Lindquist, Lohr, and Hersey (2002). This analysis combined interventions with both adults and children and found that most studies (17 out of 22 using a percentage magnitude in change approach) reported significant increases in FV intake, averaging a 16.8% or 0.6 servings per day increase. However, examining the studies that included multiple follow-ups, the magnitude of the intervention effects decreased considerably by the second follow-up. A systematic review of studies designed to increase FV intake in children from studies worldwide, 80% located in the United States, found that 9 out of 11 studies in primary school children had significant effect on FV consumption, with increases ranging from 0.3 to 0.99 servings per day. However, interventions for older children and adolescents were less successful, with only 1 out of 4 studies showing an increase of 0.32 servings per day for girls, but not for boys (Knai, Pomerleau, Lock, & McKee, 2006). Another systematic review was conducted of behavior-based FV interventions published from 2005 to 2010. Studies were limited to interventions conducted in the United States in healthy, normal-weight populations. Results showed that of the seven studies conducted in children, only three reported significant increases in FV intake, with the average daily increase estimated at +0.39 servings per day for children and adolescents (Thomson & Ravia, 2011).

The National Cancer Institute funded 9 studies (5 A Day for Better Health initiative) implementing and evaluating the efficacy of community-based FV interventions (Havas et al., 1995). Four of these were conducted in pediatric populations and were included in the Ammerman et al. (2002) review. These programs included *Gimme 5*, *5 a Day Power Plus*, *Gimme 5: A Fresh Nutrition Concept for Students*, and *High 5 Alabama*. *Gimme 5* was conducted in over 1,700 3rd graders and found that the FV intervention, compared to control, was able to modify combined FV intake and vegetable intake alone, but did not impact fruit intake during the follow-up period (Baranowski et al., 2000). The *5 a Day Power Plus* program was delivered to 4th and 5th graders at 10 schools, with 10 other schools randomized to the control groups. At follow-up, based on 24-hour recall data, no significant differences were seen for vegetable intake or combined FV intake, but were found for servings of fruit, with the intervention group having greater intake compared to the control group (Perry et al., 1998). The *Gimme 5* program for high school students followed participants from 9th to 12th grade. The intervention group had significantly greater FV consumption compared to the control group at the one-year follow-up, mainly due to the control group showing a decrease in consumption. Both groups increased similarly and the significant difference between groups remained at the two-year follow-up. Finally, the control group increased but the intervention group did not, and the groups did not differ in FV intake at the 3-year follow-up (T. A. Nicklas, Johnson, Myers, Farris, & Cunningham, 1998). The *High 5* intervention was a school-based program provided to elementary students and resulted in significant increases in fruit, vegetable, and combined FV intake at both follow-ups (years 1 and 2). Although still significantly different, the magnitude of

difference had decreased by the second follow-up between the intervention and control groups (Reynolds et al., 2000).

The *PACE+* intervention pilot program for adolescents consisted of an intervention provided in the context of primary care, followed by either no further contact or additional intervention (Patrick et al., 2001). At baseline, 42% of the adolescents reported that they ate 5 or more servings of FV each day. Although the additional intervention did not impact outcomes, the overall rates of FV intake increased by 18%, fat consumption decreased by 12%, and both changes were significant ($p = .02$ each). The *PACE+* randomized controlled trial had a similar intervention as the pilot, except it also targeted sedentary behaviors and had a control group that received an intervention on sun protection behavior (Patrick et al., 2006). Compared to the control group, the percentage increase (20.0%) in FV intake from baseline to post-intervention was near significant for girls ($p = .07$), but not for boys.

The *5 a Day Achievement Badge* program targeted African American Boy Scout's intake of FV. In the pilot study, after controlling for baseline FV intake values, the intervention group had higher intake values on vegetables and FV combined, although this was only near significant ($p = .09$) (Baranowski et al., 2002). The intervention study modified the original pilot design by conducting half of the intervention in-troop and half internet-based to reduce time burden on the troop. More than four hundred 10 – 14-year old boys participated. For intervention participants compared to control, a significant increase was found for fruit intake, but not for vegetable intake immediately following the intervention (D. Thompson et al., 2009). However, this increase was not maintained at the 6-month follow-up.

GEMS are a collection of studies to prevent weight gain in low-income African-American adolescent girls, a high-risk population (Baranowski, Baranowski, Cullen, Thompson, et al., 2003; Klesges et al., 2008; Klesges et al., 2010; Robinson et al., 2003; Robinson et al., 2008; Robinson et al., 2010; Story et al., 2003; D. Thompson et al., 2008). The Minnesota *GEMS* pilot study resulted in significant increases in dietary knowledge and healthy choice dietary behavioral intentions compared to the control condition ($p = .001$), but no significant changes for FV intake (Story et al., 2003). The Memphis *GEMS* study was conducted over a 2-year period (Klesges et al., 2008; Klesges et al., 2010). The participants had low baseline intake of FV ($M = 1.3$ servings/day). At the Year 2 follow-up, there was no change or difference between groups in fruit intake. However, vegetable intake decreased in both groups over time, but less so for the intervention group. Adjusting for baseline levels, girls in the intervention group had higher intake levels (0.9 servings versus 0.7 servings/day) ($p = .07$).

Three studies of electronic interventions have made increasing FV intake a prime focus. Two studies that used a similar platform and curriculum were the Baylor *GEMS* pilot of the *Fun Food and Fitness* program (FFFP), which combined an in-person camp and Internet follow-up, and a later study of a *Food, Fun and Fitness* (Internet-only) program (Baranowski, Baranowski, Cullen, Thompson, et al., 2003; D. Thompson et al., 2008). In the FFFP pilot study, less than half of participants participated in the internet-portion despite program efforts to incentivize log-on compliance ($M = 48\%$ compliance) and the intervention resulted in a modest increase in FV intake, although it was not significantly different than the control (Baranowski, Baranowski, Cullen, Thompson, et al., 2003). However, the Internet-only program resulted in a significant mean increase of +1.0 servings per day with participants increasing from 2.71 ($SD = 1.54$) to

3.72 ($SD = 2.42$) overall ($p = .002$) (D. Thompson et al., 2008). *Squire's Quest!*, a psychoeducational, multimedia game, was developed to increase FV consumption in 4th grade children. After controlling for baseline levels of FV intake, the post-test difference between intervention versus control was +0.91 FV servings, indicating that the game had a significant effect on FV intake ($p = .002$) (Baranowski, Baranowski, Cullen, Marsh, et al., 2003).

Overall, FV interventions are common in pediatric populations for both health promotion and obesity prevention. The interventions are largely theory-based behavioral programs. Although many of the programs are multi-faceted, there are mixed results on how effective they are in the short-term. The interventions with the largest FV intake gain (+.9-1.0 servings) have primarily been technology-based. However, few studies have capitalized on this treatment modality to date. For the FV studies that included extended follow-up, treatment gains were short-lived, indicating a need to develop novel programs that might extend the maintenance of behavior change. Mobile technologies might hold promise for this, but research is lacking in this area. The present study sought to bridge the gap by incorporating a completely novel approach to intervening on FV consumption in children and adolescents. In order to create this intervention, steps were taken to select the appropriate target population, the behavior strategies that would be employed, and the specific treatment modality.

Target population. Although a program to increase fruit and vegetable (FV) intake would be important to any demographic due to low levels of consumption across the population, the present study chose to focus on low SES, predominantly ethnic minority, older children and adolescent females. Because of the importance of prevention efforts, youth were targeted. The specific age demographic was chosen because this age group has the greatest

overall prevalence of pediatric obesity (Ogden et al., 2012a). It is a critical time in the development of obesity (W. H. Dietz, 1994), as well as a time when FV consumption decreases, making it a prime target for prevention efforts (Demory-Luce et al., 2004; Y. C. Wang et al., 2012). In addition, older children and adolescents are starting to gain autonomy over food choices (Bassett, Chapman, & Beagan, 2008; Contento, Williams, Michela, & Franklin, 2006; Dwyer et al., 2001). Furthermore, ethnic minority youth, particularly African American girls in low SES inner city neighborhoods, comprise a high-risk population due to disparities in both overweight/obesity and FV consumption (CDC, 2012c; Hedley et al., 2004; Neumark-Sztainer et al., 1996; Ogden et al., 2010; Ogden et al., 2012a; G. K. Singh et al., 2010a, 2010b; Striegel-Moore et al., 2006; Y. C. Wang et al., 2012). The sole focus on girls was further prompted by evidence that creating separate FV interventions tailored for boys and girls is necessary due to gender differences in psycho-social factors (Flynn et al., 2006; Zabinski et al., 2006).

Intervention components: Behavior change skills. An Expert Committee, commissioned by the Centers for Disease Control, the American Medical Association and the Health Resources Services Administration, identified there was strong evidence to use behavior modification techniques to support changes in diet and physical activity (Barlow, 2007). A review of interventions to impact nutrition found that behaviorally-focused interventions, which included specific behavioral targets and employed behavior change skills, tended to be more successful than knowledge-based studies (Hoelscher, Evans, Parcel, & Kelder, 2002) and a recent review found that pediatric interventions that used stimulus control, self-monitoring and a reinforcement component produced larger effect sizes than programs without these components (Dalton & Kitzmann, 2012). Behavior change skills are considered cornerstones of

behavior change and are included in most weight prevention and treatment programs (Foster et al., 2005). Specific strategies include self-monitoring; goal setting and providing reinforcement for engaging in desired behaviors; problem solving to overcome barriers; stress and contingency management; stimulus control; and social support.

Self-monitoring. Self-monitoring, or measuring one's behavior through tracking, is a strategy that has been shown to be important to change many behaviors, including dietary behaviors, and has been associated with weight loss and maintenance (Baker & Kirschenbaum, 1993; Barlow, 2007; Burke, Wang, & Sevvick, 2011; Butryn, Phelan, Hill, & Wing, 2007; Butryn et al., 2011; Freeman, 2005; Saelens & McGrath, 2003; Wing & Phelan, 2005; Yon, Johnson, Harvey-Berino, Gold, & Howard, 2007). Self-monitoring facilitates change by increasing self-awareness, identifying the target health behaviors to change, and monitoring progress toward goals. A self-monitoring component is included in most health change interventions, with paper food diaries being the most common self-monitoring tool in dietary change interventions (Burke et al., 2011). Self-monitoring via food diary utilization has been found to be an effective stand-alone intervention (Helsel, Jakicic, & Otto, 2007). In children, self-monitoring adherence has been associated with greater decreases in percent overweight after controlling for baseline percent overweight (Mockus et al., 2011). Self-monitoring can be simple or complex and research indicates that less detailed methods are just as effective in impacting health outcomes as more detailed methods (Helsel et al., 2007). Therefore, it may be advantageous to incorporate the most parsimonious types of self-monitoring into pediatric behavioral programs to facilitate adherence. Although self-monitoring can be used alone, it is usually paired with goal-setting and other behavior change skills.

Goal-setting. Setting goals has long been used as a strategy for health behavior change and to address chronic illness management within research and primary care settings (Bodenheimer & Handley, 2009; Strecher et al., 1995). Goal setting is a multi-step process which involves recognizing a reason for change, establishing a goal, selecting a goal-directed activity and self-monitoring it, and rewarding goal attainment (Cullen, Baranowski, & Smith, 2001). Feedback is also important to the goal-setting process (Shilts, Horowitz, & Townsend, 2004; Strecher et al., 1995). Three studies which reviewed goal setting to modify diet and physical activity found evidence that goal setting is an effective strategy to change these health behaviors, although many studies used the strategy in children without systematically evaluating it (Cullen et al., 2001; E. S. Pearson, 2012; Shilts et al., 2004). A later study by Shilts, Horowitz & Townsend (2009) found some benefit of adding guided goal setting to an intervention to improve dietary behavior and physical activity in low-income adolescents. Guided goal setting provides a menu of acceptable goals and then allows children or adolescents autonomy in choosing which goals to adopt. This is a helpful strategy, especially for younger children, because choosing specific and attainable goals are important to facilitating increased self-efficacy, continued work toward goals, and setting new goals (Locke & Latham, 2002). Without guidance, this process could be frustrating and counterproductive in children.

A review of studies of interventions targeting fruit and vegetable (FV) intake and dietary fat found that interventions containing a goal setting component fared better outcomes than those that did not, although the effect for FV intake was not as substantial as that for dietary fat (Ammerman et al., 2002). In pediatric populations, there is some evidence that targeting FV intake impacted the increase in daily servings for adolescents who participated in a primary

care-based intervention (Patrick et al., 2001). Those targeting FV intake increased from 3.21 (1.88) to 4.47 (1.78) servings per day, while those who did not increased from 4.91 (2.37) to 5.36 (2.20), which approached significance ($p = .09$). In the same study, targeting an increase in moderate physical activity showed a significant increase from baseline to the 4-month follow-up ($p = .001$). Another study with 4th grade children showed that goal setting and attainment impacted follow-up consumption of FV, but varied depending on baseline consumption levels, ethnicity, and number of goals set (Cullen et al., 2004). More studies are needed to determine differential impact of goal setting on FV consumption in children and adolescents.

At the individual level, behavior change skills, such as continued goal setting and self-monitoring, are important for children and adolescents to adopt to support long-term dietary changes. There is evidence that on-going goal-setting related to diet and physical activity can impact other self-management strategies, such as self-monitoring (Nothwehr & Yang, 2007), which is important to maintain changes. However these behaviors often diminish post-intervention, along with treatment gains. For example, self-monitoring can be time-consuming, relies on proactive tracking and has shown low adherence in the real-world setting (Foster et al., 2005). Ways to increase the longevity of behavior skills might be key to lasting change.

Intervention modality: Health technology and its role in dietary change interventions.

Utilizing health technology, more specifically, eHealth (e.g., Internet, kiosks, computer-based programs or games) or its counterpart mHealth—which consists of mobile health programs on mobile devices such as handheld computers, IPOD touch, tablets, Smartphones or portable gaming systems—could be the answer to increasing the reach of interventions, both in terms of the population, but also in terms of the sustainability of behavior change skills. Over the last

few years, mHealth applications (apps) have exploded onto the marketplace, with many being utilized to manage chronic health conditions, such as asthma, diabetes, HIV, smoking, and obesity (Handel, 2011). Most apps include a self-monitoring component and many also provide education and ask users to set disease self-management goals. The prime advantages of mHealth apps include their interactive nature, ability to gauge interest in a wide-scale audience, capability of housing large stores of information and tailoring content based on the user, and ability to proactively engage the user through reminders. Equally important is that mHealth apps can provide Ecological Momentary Interventions (EMI), or interventions in real-time, including reminders to engage in desired behaviors and tips and strategies for overcoming obstacles to change. This is an important feature because the benefits of periodic prompting have been recognized (Fry & Neff, 2009). However, there is a dearth of studies examining the efficacy of mHealth apps, and rigorous studies are needed (Nilsen et al., 2012). Furthermore, mHealth apps for children, especially ones that are grounded in behavior change theories, are scarce, and their development and evaluation is a much-needed area of study.

To date, most research conducted in eHealth and mHealth have utilized the Internet, CD-ROM, and handheld computers. Prior studies have demonstrated that both children and adults are willing to participate in electronic interventions and that these interventions are promising in terms of efficacy. Studies comparing traditional approaches and technology-based interventions have identified many benefits of the latter, including comparable or greater accuracy, adherence, and acceptance (Burke et al., 2005; Glanz, Murphy, Moylan, Evensen, & Curb, 2006; McClung et al., 2009; Palermo, Valenzuela, & Stork, 2004; Stone & Broderick, 2007;

Stone, Broderick, et al., 2003; Stone, Shiffman, Schwartz, Broderick, & Hufford, 2003). Real-time reminder capabilities and interactive features contribute to these benefits.

Regarding pediatric-only populations, there is building evidence that e-Health interventions, such as self-management of disease (i.e., pediatric asthma, pain, and obesity) delivered via the Internet, are effective in improving symptoms (Stinson, Wilson, Gill, Yamada, & Holt, 2009). Furthermore, a meta-analytic review of eHealth interventions to modify health behaviors (related to nutrition, physical activity, asthma and diabetes) in children and adolescents concluded that eHealth interventions with a behavioral component (self-monitoring, goal-setting, feedback) resulted in better outcomes compared to education-only interventions (Cushing & Steele, 2010). A recent review of eHealth interventions for the prevention and treatment of obesity in children and adolescents highlight that interventions with electronic components showed some efficacy, but the full effect could not be ascertained because the studies failed to separate the effects of the electronic component from other intervention components (B. Nguyen, Kornman, & Baur, 2011). This study provided further evidence that mobile technology utilization to impact weight outcomes is lacking in the pediatric population, with all studies, but one, using the Internet or CD-ROM.

The benefits of using technology to provide nutrition education and tailored intervention programs have long-been recognized (Hoelscher et al., 2002). Using technology to impact dietary behaviors and engage in other behavior strategies might be especially appealing to adolescents, who are consistently among the earliest adopters of new technologies (Borzekowski & Rickert, 2001). Research has shown that 49% of adolescents reported using the internet to find health-related information, including information about nutrition and physical

activity (Borzekowski & Rickert, 2001). There is even some evidence that adolescents are more likely to consult electronic sources than health care providers regarding health-related issues (Klein & Wilson, 2002). Thus, it is likely that technology-based health interventions may be very appealing to today's youth (Boushey et al., 2009; Casazza & Ciccazzo, 2006).

Interventions that are email or web-based, that use social networking or texting, or that use mobile devices like IPODS, cell phones or handheld computers might be among these interventions that teens find appealing. In fact, data from the Pew Research Center American Life Project found that among teens aged 12-17, 77% had cell phones and 23% had Smartphones (Pew, 2012); however among younger teens (12-13), only 57% reported having a cell phone, with 8% endorsing Smartphone ownership. Although teens from more affluent households were more likely to own cell phones, cell phone ownership was still high (62%) in households in the lowest income bracket reported. The study found that 75% of all teens text and the number of texts sent and received continues to increase, with median number of texts greatest in the lowest income bracket and among Hispanic and African American teens.

In summary, previous work indicates that eHealth interventions are a promising avenue for dietary behavior change in pediatric populations, however mHealth programs are lacking. For the current study, mHealth delivered via handheld computers was selected as the treatment modality and a program called Growing up Strong was developed. This study sought to impact goal-setting, self-monitoring and problem solving, which are cornerstones of behavior change, by taking advantage of the ability of modern mobile devices to prompt cues to action in real-time. This is the first known program to impact behaviors related to pediatric obesity

prevention that capitalizes on the ability of mobile technologies to prompt the user in real-time and which is rooted in behavior change theory.

Development and Preliminary Evaluation of Growing up Strong, a Mobile Technology Intervention Designed to Impact Fruit and Vegetable Consumption

Growing up Strong (GuS) is a mobile-technology (mHealth) intervention program grounded in behavior modification principles (goal setting, self-monitoring, cues to action) developed for use on handheld computers or other mobile devices using the Windows Mobile operating system. Its development was based in Social Cognitive Theory. The program and its development are described in full elsewhere (Nollen et al., 2012). GuS was designed to improve health and lifestyle behaviors identified and indicated by clinical practice guidelines to combat and prevent pediatric obesity (August et al., 2008; Barlow, 2007; Davis et al., 2007; L. K. Khan et al., 2009; Spear et al., 2007): increasing fruit and vegetable (FV) intake, decreasing sugar-sweetened beverage consumption and decreasing screen-time activities. Each behavior was addressed by the development of a unique module. The FV intervention was the first module of the three and is the current focus of this study. The FV intervention contains health education on topics such as serving sizes and benefits of FV. It functions to provide real-time reminders to increase daily FV intake based on goals and specific plans to meet goals selected by the user. The program requires users to track FV that are consumed in a simple food diary and enter their progress toward meeting goals in real-time. It provides feedback, rewards for interacting with it, and problem solving tips for overcoming barriers to meeting goals.

The GuS program was developed and refined through an iterative and consensus process through multiple occurrences of feedback obtained through both quantitative and qualitative (i.e., focus groups, qualitative interviews, list sorts) methodology using a Student

Advisory Board (SAB), or group of young females representing the target demographic. The program was shaped by needs assessments conducted with these SAB members in order to maximize program adoption, appeal and effectiveness. For example, the food diary, a major component facilitating the dietary self-monitoring portion of the FV intervention, and a reward system that provided incentives for responding to daily prompts were both created and added to the program in response to the iterative development process. The SAB was utilized to provide a preliminary evaluation of the fruit and vegetable intervention. This type of methodology is concurrent with typical program/product development practices, and is used in exploratory research and program/product evaluation (Heary & Hennessy, 2002; Horner, 2000; Lucasey, 2000; McGarvey et al., 2006; Wyatt, Krauskopf, & Davidson, 2008).

During the preliminary evaluation of the program, its content and functionality were examined (Nollen et al., 2012). In summary, GuS was rated favorably by the SAB. At the last iteration of the program, there were few suggestions for improving the program. The adoption of the program was high, evidenced by participants answering 78.3% of total daily prompts. These adherence rates were comparable to the rates found in studies of children using handheld computers to record pain ratings (Palermo et al., 2004; Stone, Broderick, et al., 2003). Furthermore, there was evidence that the program had a significant impact on FV consumption ($p = .03$), although this finding must be interpreted cautiously due to the small sample size ($N=15$). This study's daily increase in FV consumption (+1.77 servings) was slightly higher than other previous studies of interventions promoting fruit and vegetable consumption, which have shown an increase ranging from +.30 to +.99 servings per day (Knai et al., 2006).

Summary and Current Study

Increasing fruit and vegetable (FV) intake is an important endeavor, not only because of its relationship to weight management, but also because of its impact on overall health.

However, FV intake in children remains lower than recommended amounts, making increasing intake an integral focus for pediatric health promotion and obesity prevention programs (Lytle, 2002). There is some promising research utilizing mobile technologies (mHealth) to impact health, such as dietary behaviors, although few studies have been conducted with children. This modality would likely be appealing to children and adolescents and would have the potential to increase the reach of interventions to underserved populations.

There is some preliminary evidence that a FV intervention program grounded in behavior modification principles called Growing up Strong (GuS) is feasible and acceptable and can impact FV change based on data collected during the development process (Nollen et al., 2012). However, further testing of the intervention over a longer period of time with a larger sample of girls who were not part of the development process is needed. Extended follow-up is needed to determine maintenance of behavior change and a RCT pilot would help elucidate the effectiveness of an mHealth FV intervention compared to the traditional intervention modality for young females. To the author's knowledge, a study such as this has not been previously conducted. This paper reports the outcome of the GuS intervention to increase FV consumption in low-income ethnic minority female youth.

Aims & Hypotheses

Aim 1: To examine the immediate impact of a 4-week mobile technology intervention program, Growing up Strong (GuS), compared to a manual control condition, on change in daily

fruit and vegetable intake in adolescent females from Baseline to the end of active intervention at Week 4.

Hypothesis 1: There will be a greater increase in daily fruit and vegetable intake for participants randomized to the GuS condition compared to those in the manual control condition from Baseline to Week 4.

Aim 2: To examine the long-term impact of GuS, compared to a manual control condition, on maintenance of change in daily fruit and vegetable intake in adolescent females from Week 4 to two follow-up time-points (Weeks 8 and 12).

Hypothesis 2: Participants randomized to the GuS condition will demonstrate higher fruit and vegetable consumption across the two follow-up time-points compared to those in the manual control condition.

Aim 3: To examine the impact of GuS, compared to a manual control, on change in behavior change skills (self-monitoring/goal-setting), self-efficacy for eating fruit and vegetables, and knowledge of dietary recommendations, from Baseline to the Week 4 post-intervention assessment.

Hypothesis 3: There will be a greater increase in behavior change skills, self-efficacy for eating fruit and vegetables, and knowledge of dietary recommendations for participants randomized to the GuS condition compared to those in the manual control condition from Baseline to the Week 4 post-intervention assessment.

Aim 4: To describe acceptability of the program among participants in the GuS condition. Acceptability will be measured by adoption or usage of the GuS program and program satisfaction.

Chapter 2: Methodology

Study Design

This pilot randomized controlled trial utilized a parallel-group design in which participants were randomized to either a 4-week mobile technology intervention program (Growing up Strong), or a manual control condition. Primary outcome assessment of fruit and vegetable intake included 24-hour dietary recalls conducted during Week 4 (during active intervention). A post-intervention survey was also administered following Week 4. Additional 24-hour dietary recalls were conducted at Week 8 and Week 12 (see Figure 2).

Design considerations. Several study designs were considered in order to test the primary aim of this study, which was to examine the impact of Growing up Strong (GuS) versus a manual control on change in daily fruit and vegetable intake. A randomized trial, parallel-group design was chosen, with a ‘usual care’ control group. Parallel-group designs were important for this study to increase power and reduce needed sample size, due to the feasibility and cost-prohibitive nature of such technology-based studies. The use of a usual care control group for weight or other health behavior-targeted studies is common; however, the content of the usual care treatment varies across studies (Jenkins, McAlaney, & McCambridge, 2009; Waters, St George, Chey, & Bauman, 2012). In a review of 85 weight control trials, Waters et al. (2012) reported that usual care groups often contain health educational materials or pamphlets and may also include individual consultation or brief advice. This meta-analysis also provided evidence that only minimal weight change occurs in weight control study control groups despite the type of control group chosen (usual care, no intervention, and wait-list control), although the assignment to a usual care group versus a no intervention group was found to be a significant predictor of this minimal weight change.

For this study, the use of a manual control was selected for multiple reasons. The manual control resembles usual care, in which information and brief advice is provided to adolescents or families with little follow-up. Additionally, paper manuals or forms are the standard of care for assessing dietary behavior in both research and clinical practice. Although type of health education and associated forms or pamphlets provided vary widely in usual care, based on many factors, such as setting (e.g., research, community program, primary care, weight control clinic) or health-care provider factors, this study sought to include many of the same components that might be provided in a comprehensive program (e.g., education, brief advice, and facilitation of behavior change skills, such as self-monitoring) through providing interactive “workbook” type forms. The use of the same components in both groups, which was accomplished by using actual screenshots from the GuS program for the paper manual, allowed comparisons to address the advantages of the unique elements of mobile technology interventions (e.g., real-time reminders or cues to action, feedback and rewards).

In addition, the use of a manual control model allowed researchers to provide comprehensive health information and tools to all participants, who represent a disadvantaged and high-risk group. Furthermore, the control group was a hybrid (manual control/wait-list) in that all individuals were allowed the opportunity to complete the GuS intervention after the completion of the study. However, the group will be referred to as ‘manual control’ throughout.

Eligibility and Recruitment

Participants were recruited from 2 inner city Boys and Girls Club’s afterschool programs. Eighty-two enrollment packets were distributed to females at the study sites who were between the ages of 9 – 14. To be eligible, individuals had to be female, within the ages of 9 –

14, provide their assent and had to have parental or guardian consent. Individuals were excluded from participation if there was anything that would prevent her from being able to operate a handheld computer and/or comprehend the Growing up Strong computer program (e.g., inability to speak or read English). Thirty-six young females (43.9%) expressed interest and were screened for eligibility. All were eligible to participate. One participant was dropped before randomization due to not completing baseline measures. Thirty-five completed baseline measures and were randomized to either Growing up Strong or to a manual control group (Appendix A). No data were collected on those who received enrollment packets; therefore, it is not known how those who chose to participate were different from those who did not choose to participate.

Procedure

Individuals who expressed interest received an enrollment packet, including a letter from the investigators describing the study to give to her parent or guardian. Consent forms were signed prior to the first study visit (Figure 2). During baseline, participants completed a target of 2 (range 1 – 3) 24-hour dietary recalls at the recruitment site. Trained personnel administered dietary recalls in person with aide of kits containing standardized beverage and food models. After completing the final baseline recall, the baseline survey was administered. After the survey, the participant's height and weight were collected and the participant was randomized to one of two conditions – the Growing up Strong (GuS) intervention or manual control. Participants in the GuS condition received a tutorial on using the handheld computer and completed initial set-up of the program, which included setting a specific goal to increase daily fruit and vegetable intake by adding fruit and vegetables to one meal each. Participants in

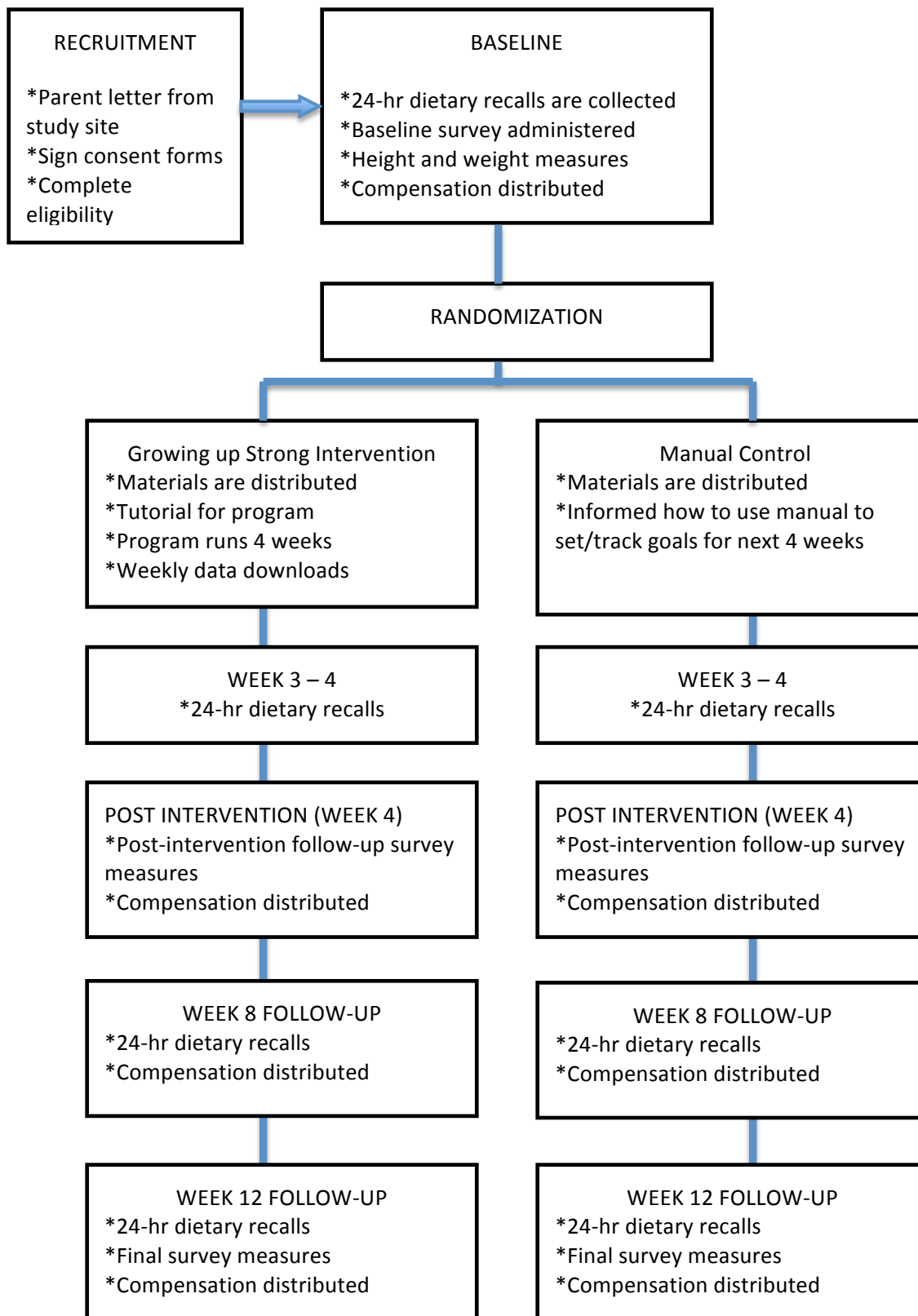


Figure 2. RCT study design showing protocol flow for each treatment group.

the manual control condition were provided a manual and information on how to utilize the manual to set goals to increase and track fruit and vegetable consumption over the ensuing 4-week period. The paper manual contained screen shots of the Growing up Strong program, therefore ensuring that identical information was conveyed in both conditions (discussed in more detail in the 'Intervention' section below.) During the subsequent four-week intervention period, usage data was downloaded weekly from participants in the GuS condition. These data downloads were conducted with minimal interaction to keep attention equivalent between conditions and involved researchers collecting devices directly from participants or through site staff and then returning the devices before the participants left for the day. Twenty-four hour dietary recalls were collected in-person for each participant in both conditions at three post-baseline time periods: Week 4, Week 8, and Week 12. The post-intervention survey was administered immediately after the intervention period (Week 4). This study was reviewed and approved by the Human Subjects Committee (HSC, #11739) at the University of Kansas Medical Center. All participants were treated in compliance with the ethical guidelines set forth by the HSC.

Intervention

Computerized Intervention. The Growing up Strong Fruit and Vegetable Module (GuS) intervention is a real-time reminder and self-monitoring mobile technology-based program that was designed to promote healthy living in adolescent females, with its primary health goal increasing fruit and vegetable consumption. It was developed utilizing an iterative approach with feedback from a Student Advisory Board, a group of young females from the target demographic (Nollen et al., 2012). It was developed utilizing behavioral change models and

includes goal setting and real-time reminders, self-monitoring, goal planning, and positive reinforcement. Goal-setting, self-monitoring and cues to action are cornerstones of behavior change, but are rarely enacted in real-time. This program was designed to improve upon usual care education and brief advice-only models by providing cues to engage in behavioral change skills. Sample screen shots are depicted in Figure 3. The program components and their operation, including a description of the 6 daily program-initiated prompts, or reminders, (morning and evening reminders plus 4 core program reminders: 2 goal and 2 goal entry), are described below.



Figure 3. Sample screen shots from the Growing up Strong program

Goal-setting and goal reminder component. During initial set-up of the program, each participant navigated through a series of screens that provided health education on fruit and vegetables (e.g., serving sizes, benefits), assessment and feedback on her fruit and vegetable intake, and a goal-setting task. This goal setting required the participant to set two goals: one to

increase her fruit intake and one to increase her vegetable intake. After set-up, three goal reminders were sent daily: one each morning with a general overview of the day's goals and two additional "real-time" goal reminders at the times she had chosen for her fruit and vegetable goals. These real-time goal reminders were 2 of the 4 core program prompts and displayed the specific goal the participant had chosen and any tips or recipes she had selected in planning to meet her goal, if applicable.

Self-monitoring component. Forty-five minutes after each set goal time, an audible goal entry reminder prompted the participant to input whether or not she met her goal (Yes or No). These goal entry reminders occurred twice daily – one for the fruit goal and one for the vegetable goal, and comprised the final 2 of the 4 core program "real-time" prompts. At this time, the participant was directed to an electronic food diary that had her input any fruit or vegetables she had consumed that day. Because children are poor estimators of serving sizes, especially when untrained (Higgins et al., 2009), the diary was designed so that the user merely input the number of times a specific fruit or vegetable was consumed. Self-monitoring with the food diary could also be user-initiated at any time through the main menu of GuS. A final opportunity to engage in self-monitoring was provided at the daily evening reminder, the final program-initiated audible prompt that sounded at a time selected by the participant at set-up.

Evening reminder. The daily evening reminder is not considered one of the program's four core "real-time" reminders, but is important in that it provided the participant an opportunity to enter whether or not she met her two goals for the day if she was unable to enter them in real-time at goal entry prompts, review her food diary and add any additional fruit or vegetables that were not entered earlier in the day, engage in goal planning for the next

day, redeem daily rewards, and receive feedback on her progress toward her goals and on her fruit and vegetable consumption.

Feedback and reward system. Feedback was provided in real-time when a participant entered whether or not she had met her goal and again at the evening reminder. These feedback opportunities reminded the participant of recommended daily fruit and vegetable intake and provided encouragement for maintaining motivation to meet goals. GuS has an integrated reward system that provided an opportunity for daily rewards based on program usage. A participant could earn and “unlock” one Mp3 of her choice from a current selection of popular songs each day by responding to 3 out of the 4 main “real-time” reminders (2 goal reminders and 2 goal entry). These rewards could be redeemed during the evening reminder.

Goal planning and other content. GuS contained several health education components that could be accessed through the main menu of the program, which was set to initiate upon turning on the device. These health education components included: “Tips and Recipes,” “Barriers,” and “Serving Sizes.” The “Tips and Recipes” provided quick tips or helpful suggestions for meeting fruit and vegetable goals and a database of healthy, easy-to-prepare recipes. In addition to accessing these through the main menu, each participant was prompted to review them every evening during the evening reminder when engaging in goal planning for the following day. If the participant did not engage in goal planning at this time, she was directed to the “quick tips” portion of “Tips and Recipes” during the following day’s corresponding real-time goal reminders. The “Barriers” component, which was also initiated in real-time in response to the participant reporting that she did not meet her goal, provided interactive screens that helped her troubleshoot common barriers to increasing fruit and

vegetable consumption (e.g., not liking the taste of fruits and vegetables). Finally, the “Serving Sizes” component was identical to the information screens provided during initial set-up of GuS on serving sizes for various forms of fruits and vegetables.

Equipment and software. The mobile technology employed with the GuS was the Asus MyPal (Model A626). This model has 128MB ROM flash memory and 64 MB RAM and 312 MHz processor. It uses Microsoft Windows Mobile, version 6.0. The Li-Ion battery yields an approximate run-time of 9 hours. A charger was provided for the device. The device is also blue-tooth enabled and has Wi-fi. It has external speakers and a 3.5mm stereo head-phone jack. Data was stored using Microsoft SQL Server software. Data files were stored on the device, but were also programmatically backed-up onto the flash drive (1 – 2 GB SD card). The data was downloaded through USB synch cable or by using the SD card to transfer files.

Manual control. The manual control group received the same information that the computerized condition received, except in a written format. The manual provided to the control group replicated the actual screen shots from the Growing up Strong (GuS) program (Figure 4). This manual provided to the control group included a goal-setting component, which had a place where the participant could select her goal and a plan for meeting the goal; a self-monitoring component, which allowed her to engage in self-monitoring by tracking the specific fruits and vegetables she consumed daily in a food diary (Figure 4); and the recipes and quick tips for meeting goals. It contained the same forms that were in the GuS program.

By providing identical information in the manual control group, the primary differences between the two groups was that the manual control lacked: prompting to engage in behavior change skills, such as goal-setting, self-monitoring and goal planning; real-time reminders to

follow-through with goals, including real-time feedback; and incentives for program engagement.

FOOD DIARY

Hi! Time to record the fruits & veggies you ate today.

BACK **NEXT**

the FRUITS I ate today...

Mark the number of times you ate each of these fruits today.

<input checked="" type="checkbox"/> 2 100% Fruit Juice	<input type="checkbox"/> Mixed Fruit/Fruit Cocktail
<input type="checkbox"/> Apple	<input type="checkbox"/> Nectarine
<input type="checkbox"/> Apricot	<input type="checkbox"/> Orange
<input type="checkbox"/> Avocado/ Guacamole	<input type="checkbox"/> Papaya
<input type="checkbox"/> Banana	<input type="checkbox"/> Peach
<input type="checkbox"/> Berries (blue/black/cran./rasp. strawberry)	<input type="checkbox"/> Pear
<input type="checkbox"/> Cherries	<input type="checkbox"/> Persimmon
<input type="checkbox"/> Fig	<input type="checkbox"/> Pineapple
<input type="checkbox"/> Grapefruit	<input type="checkbox"/> Plum
<input type="checkbox"/> Grapes	<input type="checkbox"/> Pomegranate
<input type="checkbox"/> Guava	<input type="checkbox"/> Prunes
<input type="checkbox"/> Kiwi	<input type="checkbox"/> Raisins/Dried Fruit
<input type="checkbox"/> Kumquat	<input type="checkbox"/> Tangerine
<input type="checkbox"/> Mango	<input type="checkbox"/> Other Fruits
<input type="checkbox"/> Melon (cantaloupe, honeydew, watermelon)	

4 = Total # of Fruits

Add up all the fruits you ate today & write it here.

A sample diary page may look something like this.

Figure 4. Sample page from the manual-based intervention provided to the control group.

Incentives for Participation

After completing each assessment time-point, participants received a \$10 gift card. Participants in the intervention group were loaned a handheld computer to run the GuS program and to use as an Mp3 player. They received a pair of ear buds to use with the device (\$10 value). A selection of current songs was pre-loaded onto the device and each participant had the ability to earn new songs during the 4-week intervention period based on her usage of the program. Participants in the manual control group received health educational materials in

a paper manual “workbook.” After the study was completed, the participants in the manual control group were offered the opportunity to run the GuS program, during which time they received earbuds, were loaned a device, and were able to earn songs based on program usage.

Measures

Primary outcome: Fruit and vegetable consumption. In order to examine the impact of the real-time reminder and self-monitoring intervention program on daily fruit and vegetable intake, 24-hour dietary recalls were conducted at Baseline, Week 4, Week 8 and Week 12 (Table 2). Week 4 assessment occurred during the active intervention phase to provide an indication of the immediate impact of active program engagement. Dietary recalls were conducted by trained personnel utilizing standard protocol and multiple-pass interview methodology (Conway, Ingwersen, & Moshfegh, 2004; Johnson, Driscoll, & Goran, 1996), which facilitates the standardization of the data collection process and helps minimize underreporting of food intake. This method includes distinct passes eliciting all food items or beverages that were consumed the day before; reviewing each item including the time it was consumed in order to identify and enter missed foods; gathering information about additions to foods (e.g. condiments) and collecting complete details about each item, including amounts and food preparation methods; and reviewing a final list of all information to make any necessary additions or corrections to the data. In this study, an attempt was made to collect two 24-hour dietary recalls at each assessment point, which were averaged for each participant; but single recalls were used if only one was able to be collected. The use of single 24-hour recall assessments is recommended when data is being aggregated across individuals to compare changes between groups (F. E. Thompson & Byers, 1994) and is supported over 3-day food

records in adolescents, especially when time constraints, response burden, and feasibility make the former a better option (Gomez-Marin et al., 1992). The primary outcome (number of combined daily servings of fruit and vegetables) was computed and averaged for each participant. This number included vegetable and fruit juices, but excluded fried potatoes.

Table 2
Measurement Time-Points and Description of Measures

Construct	How Measured	Measurement Timepoints			
		Baseline	Week 4	Week 8	Week 12
Primary & Secondary Outcome					
FV consumption*	24-hour dietary recall (# servings)	X	X	X	X
Aim 3 Outcomes					
Behavior Change Skills (self-monitoring, goal-setting)	2 single items, adapted from PACE	X	X		
Self-Efficacy for eating fruit and vegetables	2 items from "What I Think I Can Do"	X	X		
Knowledge of FV dietary recommendations	Single item; taken from Gimme 5	X	X		
Descriptives					
Body Mass Index	Height/Weight - percentiles calculated	X			
Demographics	YRBSS	X			
Fruit/Vegetable Home Availability	2 items collapsing fruit and vegetables	X			
Family Norms	Single item; adapted from PACE	X			
Acceptability: Usage, Satisfaction (Computerized Treatment Group Only)					
Program Usage	Usage data downloaded from devices		X		
Program Satisfaction	3 self-report 5-point Likert questions				X

*Note: FV consumption was measured in 2-week windows: Weeks 3 - 4 (during active intervention), 7 - 8 and 11 - 12. Week 4 survey measures were collected after Week 4 was complete.

Aim 3 outcomes: Behavior change variables. Impact of the program on other variables found to be related to eating habits were examined. These included behavior change skills, self-efficacy for eating fruit and vegetables, and knowledge of dietary recommendations.

Behavior change skills. Self-monitoring, or tracking fruit and vegetable intake, was assessed by a single item, which asked, "How many days last week did you count how many fruit and vegetables you ate?" Goal setting, or trying to increase fruit and vegetable intake, was assessed by a single item, which asked, "How many days last week did you make an effort to eat more fruit and vegetables?" Response options for both items were scaled from 0 days to 7

days or “everyday.” These questions were adapted from behavior change strategy questions from PACE and relate specifically to the behavior change targeted by GuS (Patrick et al., 2001).

Self-efficacy. Self-efficacy for eating fruit and vegetables was measured separately with two single items. These items stated “I am sure that I could eat fruit/vegetables 2 or more/3 or more times a day.” Response options were scaled from 1 (not sure) to 3 (very sure). These items were adopted from “What I Think I Can Do” questionnaire from the Boy Scout 5-a-Day Badge program (Baranowski et al., 2002; Jago et al., 2006; D. Thompson et al., 2009).

Knowledge of dietary recommendations. Participant knowledge of daily recommended amounts of fruit and vegetables was assessed through a single item, which asked “How many fruit and vegetables should you eat each day?” Response options were categorical and included “1 serving,” “2 servings,” “3 servings,” “4 servings,” “5 or more servings,” and “don’t know.” This single item has been used in other fruit and vegetable intervention studies (Reynolds et al., 2004). This same item has also been included in tandem with questions assessing knowledge of strategies to add fruit and vegetables to one’s diet in the GIMME 5 intervention targeting fruit and vegetable intake (Baranowski et al., 2000). Baseline and post-intervention categories were collapsed into “accurate” (5 servings or more) or “inaccurate” (all other response options). Those who were accurate at baseline were excluded from analyses. The remaining participants were categorized as either knowledge did “1” or did not “0” change from inaccurate to accurate from Baseline to Week 4.

Process outcomes: Acceptability (usage, satisfaction). Acceptability was measured by assessing usage of the program and participant satisfaction with the program among participants in the GuS condition only. Usage data was extracted from time and date-stamped

records within the program tracking number of program-initiated prompts to which the participant responded. Response to the six daily program-initiated prompts was explored and summarized. At the Week 12 assessment, satisfaction was assessed through 5-point Likert scaled self-report questions asking “How much did you like this program?” “Would you recommend this program to a friend?” and “Would you do this program again?” The participants were also asked to rank order their favorite components of the program: goal setting; reminders; diary; tips and recipes; and reward system.

Participant, home and family variables. Other descriptive variables were collected at baseline: demographic variables, including height, weight and BMI percentile; home availability of fruit and vegetables; and family norms regarding fruit and vegetable consumption.

Socio-demographic variables. Demographic characteristics included age, race, ethnicity, height/weight and BMI percentile. Ethnicity and race were assessed through the 2 standardized questions from the Youth Behavior Risk Surveillance. Height and weight were taken with participants in street clothes with shoes removed using a stationary measuring device and a digital scale (Befourt, Model PS5700). BMI percentiles were calculated using the CDC’s 2000 growth charts (Kuczmarski et al., 2002; Ogden et al., 2002).

Home availability. Availability of fruit and vegetables in the home is often measured by utilizing a list of fruit and a list of vegetable items and having the participant state whether each item is available in the home (Baranowski, Baranowski, Cullen, Thompson, et al., 2003; Baranowski et al., 1998; Robinson et al., 2003). In order to reduce response burden, 2 single items were asked: “At home, do you have fruit (vegetables) to eat?” Response categories were categorical: “never,” “sometimes,” “always,” and “I don’t know.”

Family norms. This was assessed with a single item that asked the participant to rate how often her parent(s) eat fruit and vegetables. The response options were categorical and included: “never,” “1 – 2 days per week,” “3 – 4 days per week,” “5 – 6 days per week,” and “Everyday.” This question was adapted from one of the family support questions from the PACE (Patrick et al., 2001).

Data Treatment

All survey data were entered into REDCap and verified for accuracy before being transferred into SPSS (version 20.0). Dietary recalls were entered into the Nutrition Data System for Research Software (NDSR) by a licensed dietitian, who conducted a comprehensive nutrient analysis and calculated number of daily servings of fruit and vegetables. After being processed, this summarized data was provided to researchers in a Microsoft® Excel document, which was then merged into SPSS. Usage data from the GuS program was stored using Microsoft® SQL Server software and was transferred from handheld computers onto a secure server. The files were named with a unique identifier linking the data file to the participant who used the handheld computer. All usage data files were then compiled and transferred into SPSS for analysis.

Data Analysis

All statistical analyses were conducted with SPSS (version 20.0). All analyses employed two-tailed tests, with alpha set to .05. Comparisons were conducted to assure the equivalency of intervention and control group participants on key baseline measures using independent sample t-tests for scaled variables and chi-square for categorical variables. Frequencies or

means and standard deviations were calculated and reported for descriptive and process outcome variables.

To address Aims 1 and 2, which was to examine the impact of GuS on change in daily fruit and vegetable intake in adolescent females compared to a manual control, Mixed ANOVA was utilized. Group was input as the between-subjects factor and assessment time-point as the within-subjects independent factor (Group*Time). ANCOVA was also utilized, using baseline values as the covariate for Aim 1 and Week 4 values as the covariate for Aim 2 analyses.

To address Aim 3, which was to examine the impact of the intervention on behavior change skills (self-monitoring/goal-setting), self-efficacy for eating fruit and vegetables, and knowledge of dietary recommendations, each variable was assessed at baseline and immediately post-intervention. Mixed ANOVA (Group*Time) was used to test the impact of the intervention on the behavior change skills and self-efficacy items, which were interval dependent variables. ANCOVA was also utilized using baseline values as the covariate. To test the impact of GuS on knowledge of dietary recommendations, Chi Square was used.

Sample Size and Power Analysis

In a previous pilot study with young females ($N = 13$), the GuS intervention was shown to increase fruit and vegetable intake from 4.0 ($SD = 2.3$) to 5.6 ($SD = 2.8$) servings per day (Nollen et al., 2012). Effect sizes were computed using paired t-test values (Rosenthal, 1991). Although this is a less conservative estimate than using between-group t-test values (Dunlop, Cortina, Vaslow, & Burke, 1996), there are limited trials using technology such as this to increase FV intake in adolescents. The resulting analysis yielded a medium effect size (Cohen's $d = 0.624$; effect-size $r = 0.298$). Assuming a similar effect size with the anticipated sample size of

36, *G-power* was used to calculate statistical power for the planned mixed ANOVAs for the primary analysis with two measurements and two-tailed analyses (Faul, Erdfelder, Buchner, & Lang, 2009). With an anticipated sample size of 36, this study was designed to have 95% power to detect a similar effect ($\eta^2 = .089$); 82% power to detect a medium effect ($\eta^2 = .06$); and 99% power to detect a large effect ($\eta^2 = .14$).

Chapter 3: Results

Participant Characteristics

Participants were on average 11.29 ($SD = 1.82$; range, 9 – 15) years of age and were predominantly African American (80.0%) and non-Hispanic (91.4%; Table 3). Socioeconomic level was determined by calculating % below poverty level and median household salary based on zip code analysis of the 2000 census data. The average median household salary for the neighborhoods in which the participants lived was \$24,834.60, which is at the 108% Federal Poverty Level for a family of 4 (USDHHS, 2012). Body mass index ($M = 23.7$; $SD = 5.92$) was determined from baseline height and weight measures. Participant's BMI-for-age percentiles were calculated using the CDC's 2000 growth charts. None of the participants were classified as underweight ($< 5^{\text{th}}$ percentile); 45.7% ($N = 16$) were healthy weight (5^{th} to less than the 85^{th} percentile); 14.3% ($N = 5$) were overweight (85^{th} to less than the 95^{th} percentile) and 40.0% ($N = 14$) were obese (equal to or greater than the 95^{th} percentile). Among the 35 participants, 14.3% ($N = 5$) also fell above the 99^{th} BMI percentile for age. Utilizing 2-tailed independent t-tests, participants in the intervention and control group did not differ on baseline measures of age, SES, or BMI percentile ($p > .05$).

Most participants (54.3%) reported that they sometimes have fruit available at home, with 45.7% reporting that they always have it available (Table 3). Most participants (65.7%) reported that they always have vegetables available at home, with 31.4% reporting that they sometimes have vegetables available. Participants reported that their parent or parents primarily eat fruit and vegetables "3 – 4 days" per week (37.1%). An equal number of participants (22.9% each) reported that their parent or parents eat fruit and vegetables "1 – 2

days” per week or “everyday.” Some participants reported that their parent or parents eat fruit and vegetables “5 – 6 days” per week (14.3%) or “never” (2.9%).

Table 3
Baseline Participant Demographics

	Mean (SD) or %
Age	11.29 (1.82)
Race	
<i>African American (%)</i>	80.0
<i>American Indian or Alaskan Native (%)</i>	8.6
<i>Multiracial (%)</i>	8.6
<i>Caucasian (%)</i>	2.9
<i>Asian or Pacific Islander (%)</i>	2.0
Ethnicity (% non-Hispanic)	91.4
Neighborhood SES (average % below poverty level)	27.0
Eat school breakfast (%)	60.0
BMI (% at or above 95 th percentile)	40.0
Computer in the home (% of participants with 1 or more)	85.7
Fruit Home Availability (% that always have fruit)	45.7
Vegetable Home Availability (% that always have veg.)	65.7
Parents Norms (% who eat fruit/vegetables every day)	22.9

Notes: *N* = 35

Primary Outcome: Fruit and Vegetable Consumption

Dietary recalls were collected for all participants (*N* = 35) at Baseline and Week 4, for 34/35 participants at Week 8 and 31/35 participants at Week 12 (Figure 5). With a target of 2 recalls per time-point, an average of 2.46, 2.17, 2.03 and 1.68 were collected at baseline, Weeks 4, 8, and 12, respectively.

Aim 1: To examine the immediate impact of Growing up Strong (GuS) compared to a manual control condition on change in daily fruit and vegetable intake from Baseline to Week

4. All significance values are reported using two-tailed tests. Baseline values on average fruit and vegetable combined daily intake did not differ between the manual control (*N* = 17, *M* = 2.41, *SD* = 1.70) and GuS condition (*N* = 18, *M* = 2.31, *SD* = 1.43; *t*(33) = 0.19, *p* = .85) (Figure 6).

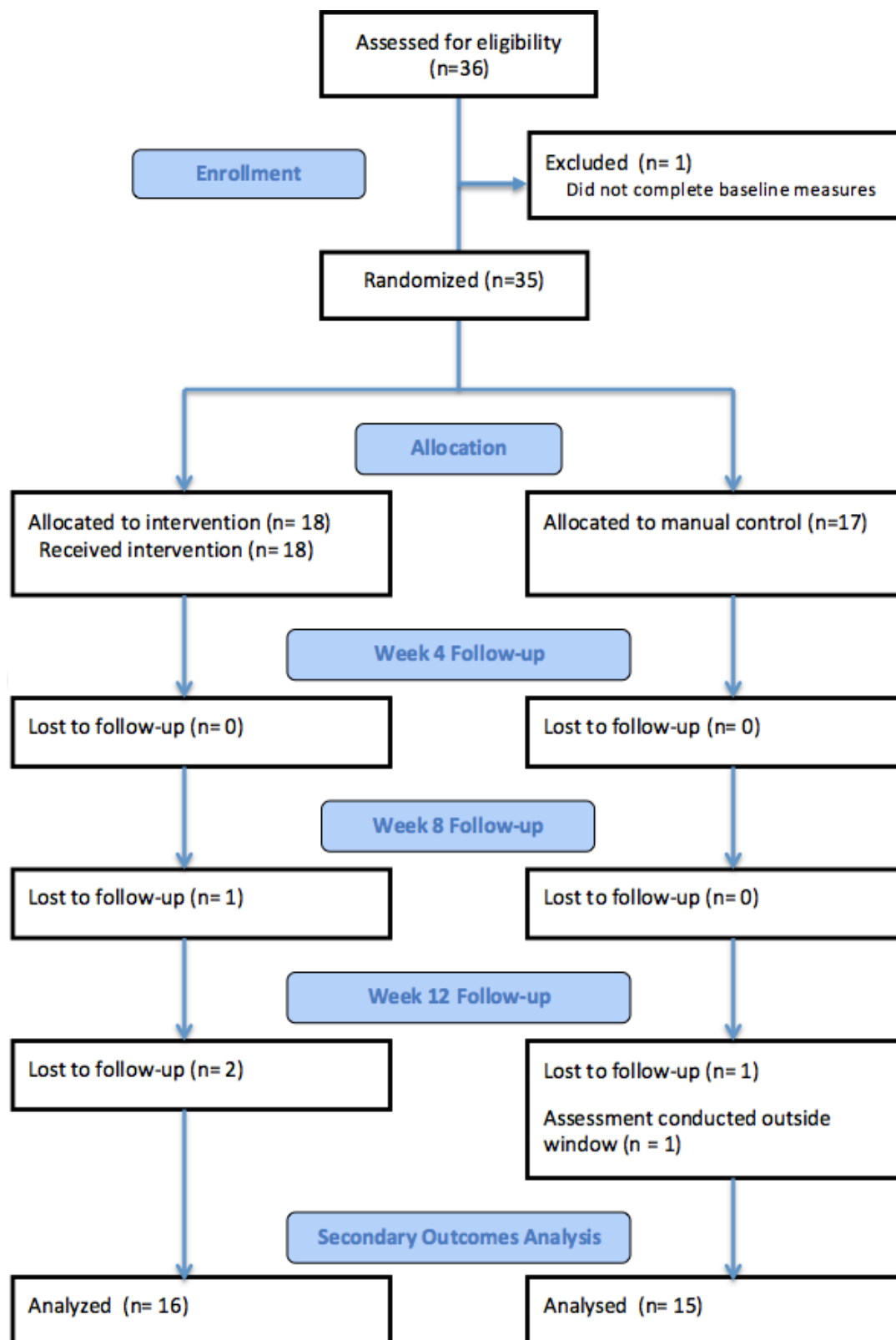


Figure 5: Participant flow diagram from Baseline to Week 12 Follow-up

A 2 (Group) x 2 (Time) Mixed ANOVA was conducted. Neither Group, $F(1, 33) = 2.07, p = .16$, partial $\eta^2 = .059$, nor Time, $F(1, 33) = 0.53, p = .471$, partial $\eta^2 = .016$, had a significant effect on FV intake. However, the interaction (Group*Time) was near significant, $F(1, 33) = 3.36, p = .076$, partial $\eta^2 = .093$ (Figure 6). Paired comparisons showed that the GuS group had a significantly higher FV intake at Week 4 ($M = 3.22, SD = 1.56$) compared to the manual control group ($M = 2.02, SD = 1.51$), $t(33) = 2.32, p = .026$. Furthermore, the GuS group showed a near significant increase in FV intake from Baseline to Week 4, $t(17) = 2.00, p = .06$. In contrast, the manual control group showed a decrease in FV intake across this same interval, although the change was not significant, $t(16) = 0.71, p = .49$.

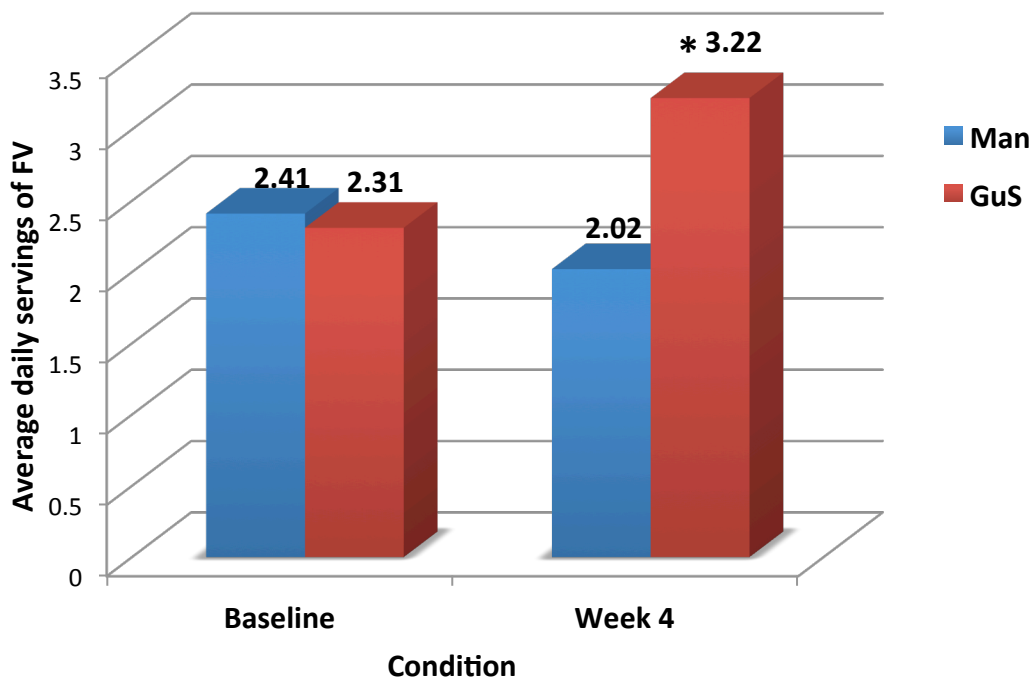


Figure 6. Fruit and vegetable consumption from Baseline to Week 4 by condition. *Controlling for Baseline FV intake, ANCOVA results showed that the Growing up Strong (GuS) group ($N = 18$) had higher FV intake than Manual Control (Man) group ($N = 17$) at Week 4 (partial $\eta^2 = .143$).

A one-way analysis of covariance (ANCOVA) was conducted with Group set as the independent variable with two levels, Week 4 FV intake values as the dependent variable and

Baseline FV intake values as the covariate. A preliminary analysis to test the homogeneity-of-regression assumption showed that the relationship between the covariate and dependent variable did not differ significantly as a function of the independent variable, $F(1, 31) = 0.24, p = .627$. The ANCOVA was significant, $F(1, 31) = 5.33, p = .028$. The results showed that individuals in the GuS group had significantly higher FV intake at Week 4, controlling for the effect of their Baseline FV intake, compared to participants in the manual control group, partial $\eta^2 = .143$.

Exploratory sub-analyses. Additional analyses were conducted to examine change in daily intake separately for fruits and vegetables. Utilizing independent sample t-tests, baseline fruit intake was not significantly different between GuS ($N = 18, M = 0.77, SD = 0.67$) and manual control ($N = 17, M = 1.06, SD = 1.11$) conditions, $t(26.04) = 0.93, p = .363$ (Figure 7). Levene's test indicated unequal variances ($F = 4.48, p = .042$), resulting in a degrees of freedom adjustment from 33 to 26.04. Additionally, baseline vegetable intake did not differ between GuS ($M = 1.54, SD = 1.15$) and manual control ($M = 1.35, SD = 1.15$) conditions, $t(33) = 0.49, p = .630$.

A 2 (Group) x 2 (Time) Mixed ANOVA was conducted for fruit intake. The main effect of Group was not significant, $F(1, 33) = 1.28, p = .265$, partial $\eta^2 = .037$. The main effect of Time on fruit intake was near significant, $F(1, 33) = 3.45, p = .072$, partial $\eta^2 = .095$. The interaction (Group*Time) was significant, $F(1, 33) = 6.78, p = .014$, partial $\eta^2 = .17$ (Figure 7). Paired comparisons on the interaction revealed that the GuS group had a significantly higher fruit intake at Week 4 ($M = 1.74, SD = 1.21$) compared to the manual control group ($M = 0.90, SD = 0.75$), $t(33) = 2.46, p = .019$. The GuS group had a significant increase in fruit intake from Baseline to Week 4, $t(17) = 3.22, p = .01$. However, the manual control group experienced a

decrease in fruit intake from Baseline to Week 4. This change was not significant, $t(16) = 0.52$, $p = .61$. A one-way analysis of covariance (ANCOVA) was conducted with Group set as the independent variable with two levels, Week 4 fruit intake values as the dependent variable and Baseline FV intake values as the covariate. A preliminary analysis to test the homogeneity-of-regression assumption showed that the relationship between the covariate and dependent variable did not differ significantly as a function of the independent variable, $F(1, 31) = 0.34$, $p = .562$. The ANCOVA was significant, $F(1, 31) = 6.28$, $p = .017$. The results showed that individuals in the GuS group had significantly higher fruit intake at Week 4, controlling for the effect of Baseline fruit intake, compared to participants in the manual control group, partial $\eta^2 = .164$.

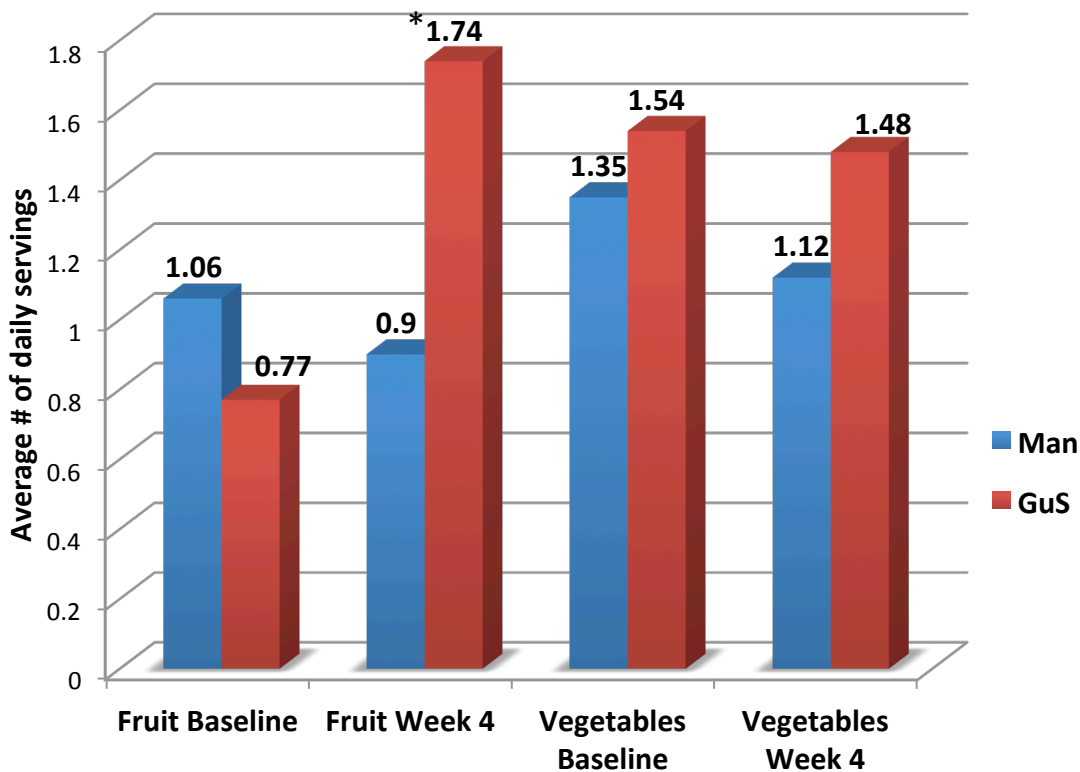


Figure 7. Fruit and vegetable consumption considered separately--Baseline to Week 4 changes by condition. *Fruit intake significantly increased from Baseline to Week 4 for Growing up Strong (GuS) group ($N = 18$, $p = .01$) and was higher than Manual Control (Man) group ($N = 17$) at Week 4 ($p = .019$).

A 2 (Group) x 2 (Time) Mixed ANOVA was conducted for vegetable intake. Neither Group, $F(1, 33) = 0.99, p = .327$, partial $\eta^2 = .029$, nor Time, $F(1, 33) = 0.34, p = .564$, partial $\eta^2 = .010$, had a significant effect on vegetable intake. The interaction (Group*Time) was not significant, $F(1, 33) = 0.13, p = .722$, partial $\eta^2 = .004$ (Figure 7). Vegetable intake did not differ between the GuS ($M = 1.48, SD = 1.06$) and manual control ($M = 1.12, SD = 1.03$) conditions at Week 4, $t(33) = 1.03, p = .309$. The manual control group showed a decline in vegetable intake from Baseline to Week 4, although this was not significant, $t(16) = 0.59, p = .56$. Likewise, the GuS group showed a decrease in vegetable intake, which was also not significant, $t(17) = 0.18, p = .86$. A one-way analysis of covariance (ANCOVA) was conducted with Group set as the independent variable with two levels, Week 4 vegetable intake values as the dependent variable and Baseline FV intake values as the covariate. A preliminary analysis to test the homogeneity-of-regression assumption showed that the relationship between the covariate and dependent variable did not differ significantly as a function of the independent variable, $F(1, 31) = 1.70, p = .202$. The ANCOVA was not significant, $F(1, 31) = 0.93, p = .343$.

Secondary Outcome: Fruit and Vegetable Intake Maintenance

Aim 2: To examine the long-term impact of GuS compared to a manual control condition on maintenance of change in daily fruit and vegetable (FV) intake from Week 4 to Weeks 8 and 12. Four participants (11.4%; 2 each condition) were dropped from maintenance analyses (Figure 5). A 2 (Group) x 4 (Time) Mixed ANOVA was conducted to examine the change in FV intake over time for the remaining 31 participants. Neither Time, $F(3, 87) = 1.77, p = .159$, partial $\eta^2 = .057$; nor Group, $F(1, 29) = 1.28, p = .267$, partial $\eta^2 = .042$, had a significant effect

on FV intake. The interaction (Group*Time) was not significant, $F(3, 87) = 0.95$, $p = .421$, partial $\eta^2 = .032$ (Figure 8).

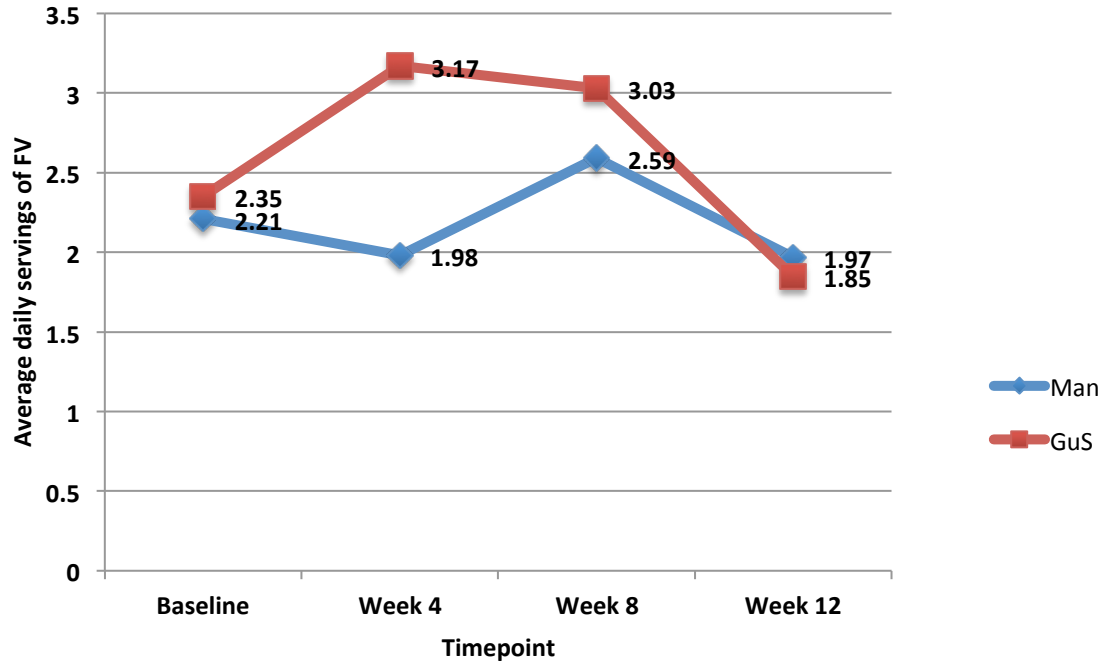


Figure 8. Total fruit and vegetable consumption across time by condition. Analyses were conducted for 31 participants completing all time-points in the Manual Control (Man; $N = 15$) and Growing up Strong (GuS, $N = 16$) groups.

The GuS group had a significantly higher FV intake at Week 4 ($N = 16$, $M = 3.17$, $SD = 1.44$) compared to the manual control group ($N = 15$, $M = 1.98$, $SD = 1.56$), $t(29) = 2.21$, $p = .035$. There was no difference in FV intake between the GuS ($M = 3.03$, $SD = 2.81$) and manual control ($M = 2.59$, $SD = 1.82$) at Week 8, $t(29) = 0.52$, $p = .61$. Likewise, there was no difference between the GuS ($M = 1.85$, $SD = 1.08$) and manual control ($M = 1.97$, $SD = 1.55$) at Week 12, $t(29) = 0.25$, $p = .803$. For the GuS group, the changes in FV intake from Baseline to Week 4, $t(15) = 1.66$, $p = .118$, from Week 4 to Week 8, $t(15) = 0.19$, $p = .854$, and from Week 8 to Week 12, $t(15) = 1.86$, $p = .083$, were not significant utilizing 2-tailed correlated t-tests. However, the increase from Baseline to Week 4 and the decrease from Week 8 to 12 were near significant.

For the manual control group, the changes in FV intake from Baseline to Week 4, $t(14) = 0.38$, $p = .711$, from Week 4 to Week 8, $t(14) = 0.97$, $p = .348$, and from Week 8 to Week 12, $t(14) = 0.96$, $p = .355$, were not significant. Both groups had lost all treatment gains by Week 12.

To gauge maintenance after the treatment period, a mixed factorial analysis of covariance (ANCOVA) was implemented. Group was set as the between subjects factor and Time (Week 8 and Week 12) was set as the within subjects factor. Week 4 FV intake values were input as the covariate. Homogeneity-of-regression assumption was confirmed. The covariate and (Time*Group) interaction was not significant, $F(1, 27) = 0.20$, $p = .662$. The ANCOVA was not significant, $F(1, 28) = 0.65$, $p = .425$ (Table 4). There was no difference between the two groups, controlling for the effect of Week 4 FV intake values.

Table 4
Analysis of Covariance Summary: FV Consumption Week 8 to Week 12

Source	Sum of Squares	df	Mean Square	F	p	Partial Eta Squared
<i>Within-Subject Effects</i>						
Time	7.43	1	7.43	2.30	.141	.076
Time*Week 4 FV Intake	1.30	1	1.30	0.40	.532	.014
Time*Group	2.12	1	2.12	0.65	.425	.023
Error	90.65	28	3.24			
<i>Between-Subject Effects</i>						
Week 4 FV Intake	3.92	1	3.92	0.91	.347	.032
Group	0.03	1	0.03	0.01	.936	.000
Error	120.27	28	4.30			

*Note: Week 4 Fruit and Vegetable (FV) Intake is the covariate.

Exploratory sub-analyses. Additional analyses examined the maintenance of daily intake separately for FV for the 31 participants who completed all 4 time-points. A 2 (Group) x 4 (Time) Mixed ANOVA was conducted to examine the change in fruit intake over time (Figure 9). Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(5) = 25.99$, $p <$

.001, therefore corrections were used based on Huynh-Feldt estimates of sphericity ($\epsilon = .688$).

The main effect of Time, $F(2.06, 59.85) = 3.20$, $p = .046$, partial $\eta^2 = .099$, was significant.

However, the main effect of Group, $F(1, 29) = 1.03$, $p = .319$, partial $\eta^2 = .034$, and the interaction (Group*Time) were not significant, $F(2.06, 59.85) = 1.46$, $p = .241$, partial $\eta^2 = .048$.

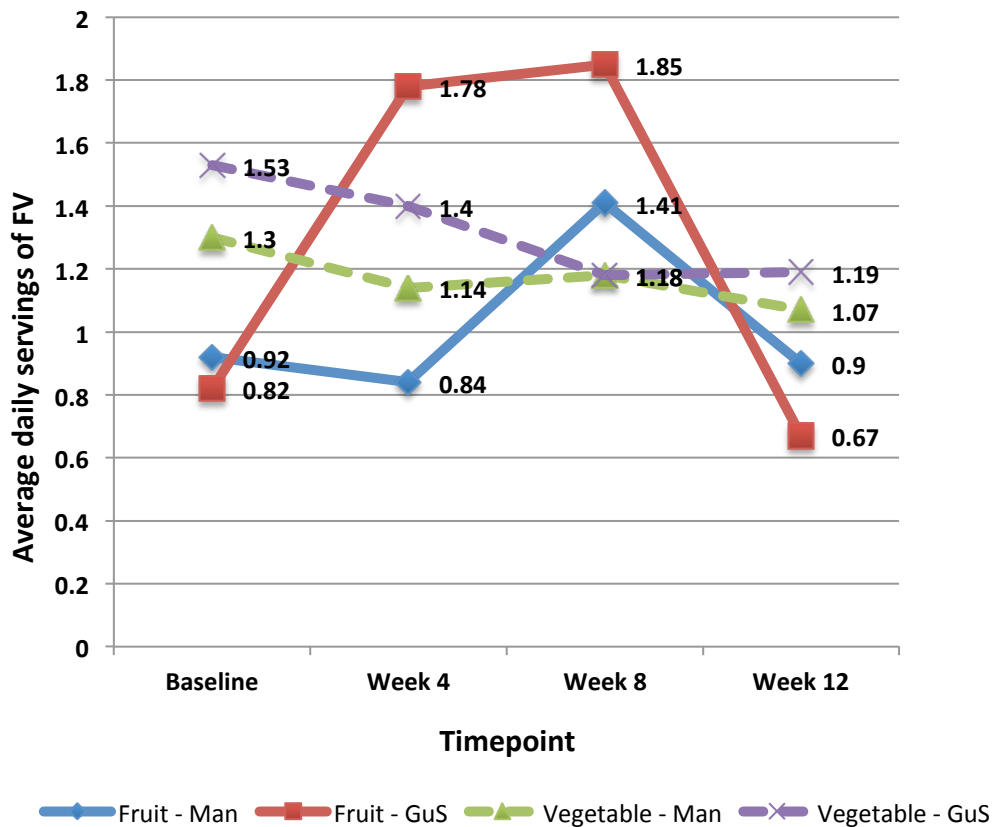


Figure 9. Fruit and vegetable consumption, considered separately, across time by condition. Analyses were conducted for 31 participants completing all time-points in the Manual Control (Man; $N = 15$) and Growing up Strong (GuS, $N = 16$) groups.

At Week 4, the GuS group had a significantly higher fruit intake ($M = 1.78$, $SD = 1.17$) compared to the manual control group ($M = 0.84$, $SD = 0.78$), $t(29) = 2.61$, $p = .014$. At Week 8, there was no difference in fruit intake between the GuS ($M = 1.85$, $SD = 2.45$) and manual control group ($M = 1.41$, $SD = 1.41$), $t(29) = 0.60$, $p = .553$. At Week 12, there was no difference in fruit intake between the GuS ($M = 0.67$, $SD = 0.79$) and manual control group ($M = 0.90$, $SD =$

0.99), $t(29) = 0.75$, $p = .462$. For the GuS group, the increase in fruit intake from Baseline to Week 4 was significant, $t(15) = 2.94$, $p = .01$. The slight increase in fruit intake from Week 4 to Week 8, $t(15) = 0.10$, $p = .919$, was not significant; however, the subsequent decline in fruit intake from Week 8 to Week 12, $t(15) = 1.74$, $p = .103$, was near significant utilizing 2-tailed correlated t-tests. For the manual control group, the slight decrease in fruit intake from Baseline to Week 4 was not significant, $t(14) = 0.21$, $p = .838$. The increase in fruit intake from Week 4 to Week 8, $t(14) = 1.51$, $p = .154$, and the decline from Week 8 to Week 12, $t(14) = 1.36$, $p = .194$, were not significant utilizing 2-tailed correlated t-tests.

To examine fruit intake maintenance after the treatment period, a mixed factorial analysis of covariance (ANCOVA) was conducted. Group was set as the between subjects factor and Time (Week 8 and Week 12) was set as the within subjects factor. Week 4 fruit intake values were input as the covariate. Homogeneity-of-regression assumption was confirmed. The covariate and (Time*Group) interaction was not significant, $F(1, 27) = 0.001$, $p = .977$. The ANCOVA was not significant, $F(1, 28) = 1.20$, $p = .282$ (Table 5). There was no difference between the two groups, controlling for the effect of Week 4 fruit intake values.

Table 5

Analysis of Covariance Summary: Fruit Consumption Week 8 to Week 12

<i>Source</i>	<i>Sum of Squares</i>	<i>df</i>	<i>Mean Square</i>	<i>F</i>	<i>p</i>	<i>Partial Eta Squared</i>
<i>Within-Subject Effects</i>						
Time	8.70	1	8.70	3.53	.071	.112
Time*Week 4 Fruit Intake	1.46	1	1.46	0.59	.447	.021
Time*Group	2.96	1	2.96	1.20	.282	.041
Error	68.96	28	2.46			
<i>Between-Subject Effects</i>						
Week 4 Fruit Intake	3.99	1	3.99	1.68	.205	.057
Group	0.27	1	0.27	0.12	.737	.004
Error	66.35	28	2.37			

A 2 (Group) x 4 (Time) Mixed ANOVA was conducted to examine the change in vegetable intake over time (Figure 9). Mauchly's test indicated that the assumption of sphericity had been met, $\chi^2(5) = 2.90, p = .715$. Neither Time, $F(3, 87) = 0.49, p = .688$, partial $\eta^2 = .017$, nor Group, $F(1, 29) = 0.52, p = .476$, partial $\eta^2 = .018$, had a significant effect on vegetable intake and the interaction (Group*Time) was not significant, $F(3, 87) = 0.11, p = .954$, partial $\eta^2 = .004$.

At Week 4, there were no differences in vegetable intake between the GuS group ($M = 1.40, SD = 1.06$) and the manual control group ($M = 1.14, SD = 1.07$), $t(29) = 0.68, p = .502$. At Week 8, there was no difference in vegetable intake between the GuS ($M = 1.18, SD = 0.83$) and manual control group ($M = 1.18, SD = 0.96$), $t(29) = 0.02, p = .984$. At Week 12, there was no difference in vegetable intake between the GuS ($M = 1.19, SD = 0.85$) and manual control group ($M = 1.07, SD = 1.09$), $t(29) = 0.34, p = .737$. For the GuS group, the decrease in vegetable intake from Baseline to Week 4, $t(15) = 0.41, p = .687$ and further decline from Week 4 to Week 8, $t(15) = 0.81, p = .43$, were not significant utilizing 2-tailed correlated t-tests. Furthermore, the slight increase from Week 8 to Week 12 was not significant, $t(15) = 0.02, p = .982$. For the manual control group, the decrease in vegetable intake from Baseline to Week 4, $t(14) = 0.36, p = .725$, and the increase from Week 4 to Week 8, $t(14) = 0.11, p = .913$ was not significant utilizing 2-tailed correlated t-tests. The decline from Week 8 to Week 12, $t(14) = 0.24, p = .812$, was not significant, as well.

To examine vegetable intake maintenance after the treatment period, a mixed factorial analysis of covariance (ANCOVA) was conducted. Group was set as the between subjects factor and Time (Week 8 and Week 12) was set as the within subjects factor. Week 4 vegetable intake

values were input as the covariate. Homogeneity-of-regression assumption was confirmed. The covariate and (Time*Group) interaction was not significant, $F(1, 27) = 0.61, p = .552$.

The ANCOVA was not significant, $F(1, 28) = 0.05, p = .834$ (Table 6). There was no difference between the two groups, controlling for the effect of Week 4 vegetable intake values.

Table 6

Analysis of Covariance Summary: Vegetable Consumption Week 8 to Week 12

Source	Sum of Squares	df	Mean Square	F	p	Partial Eta Squared
<i>Within-Subject Effects</i>						
Time	0.02	1	0.02	0.02	.883	.001
Time*Week 4 Vegetable Intake	0.001	1	0.001	0.001	.974	.000
Time*Group	0.05	1	0.05	0.05	.834	.002
Error	28.55	28	1.02			
<i>Between-Subject Effects</i>						
Week 4 Vegetable Intake	1.83	1	1.83	2.50	.125	.082
Group	0.01	1	0.01	0.01	.931	.000
Error	20.46	28	0.73			

Behavior Change Skills, Self-efficacy, and Knowledge

Aim 3: To examine the impact of GuS, compared to a manual control, on change in behavior change skills (self-monitoring/goal-setting), self-efficacy for eating fruit and vegetables, and knowledge of dietary recommendations from Baseline to the Week 4 post-intervention assessment. Baseline values on self-monitoring, measured by number of days participants tracked their fruit and vegetable consumption in the past week, did not differ significantly between the manual control ($N = 17$) and GuS ($N = 18$) conditions, $t(33) = 0.99, p = .326$ (Table 7). A 2 (Group) x 2 (Time) Mixed ANOVA was implemented. Both Group, $F(1, 33) = 7.07, p = .012$, partial $\eta^2 = .177$, and Time, $F(1, 33) = 6.88, p = .013$, partial $\eta^2 = .172$, had a statistically significant effect on self-monitoring. However, the interaction (Group*Time) was not significant, $F(1, 33) = 1.19, p = .282$, partial $\eta^2 = .035$. The GuS group reported a

significantly higher number of days tracking, compared to the manual control group, at Week 4 $t(33) = 3.31, p = .002$. The GuS group reported a significant increase (+2.0 days) in days spent tracking from Baseline to Week 4, $t(17) = 3.25, p = .005$; however, the manual control group did not report a significant change (+0.83 days) in tracking days reported during the same interval, $t(16) = 0.92, p = .372$. Analysis of Covariance (ANCOVA) was conducted with baseline self-monitoring values used as the covariate. The assumption of homogeneity of variance was met and the analyses showed that the results did not alter the findings based on the Mixed ANOVA—the GuS had higher scores at Week 4 compared to manual control after controlling for baseline values, $F(1, 35) = 10.07, p = .003$, partial $\eta^2 = .239$.

Table 7
Aim 3 Outcomes: Behavior Change Skills and Self-efficacy

	Study arm	Baseline M (SD)	Week 4 M (SD)
Count how many FV were eaten (# days in last 7)	Manual	2.82 (2.68)	3.65 (2.09)
	GuS	3.72 (2.65)	5.72 (1.60)
Make an effort to eat more FV (# days in last 7)	Manual	2.76 (2.80)	4.71 (2.20)
	GuS	4.67 (2.06)	5.83 (1.98)
Self-efficacy (how sure she can eat fruit 2+ times/day)	Manual	2.47 (0.80)	2.65 (0.61)
	GuS	2.83 (0.38)	2.78 (0.43)
Self-efficacy (how sure she can eat vegetables 3+ times/day)	Manual	2.06 (0.75)	2.18 (0.53)
	GuS	2.44 (0.71)	2.61 (0.61)

Notes: $N = 35$; GuS = Growing up Strong computerized intervention; Manual = Manual control group

Baseline values on goal-setting, measured by number of days participants made an effort to increase their fruit and vegetable (FV) intake in the past week, were significantly different between the manual control and GuS conditions, with the GuS group having almost a 2 day average greater than the manual control group, $t(33) = 2.30, p = .028$ (Table 7). A 2 (Group) x 2 (Time) Mixed ANOVA was implemented. Both Group, $F(1, 33) = 6.29, p = .017$,

partial $\eta^2 = .16$, and Time, $F(1, 33) = 10.66, p = .003$, partial $\eta^2 = .244$, had a statistically significant effect on goal setting. However, the interaction (Group*Time) was not significant, $F(1, 33) = 0.66, p = .422$, partial $\eta^2 = .02$. Utilizing 2-tailed independent t-tests, days spent making an effort to increase FV intake, did not differ significantly between the manual control and GuS groups at Week 4, $t(33) = 1.60, p = .120$. The GuS group reported a near significant increase (+1.16 days) in days spent making an effort to increase FV intake from Baseline to Week 4, $t(17) = 1.84, p = .083$; however, the manual control group did report a significant change (+1.95 days) during the same interval, $t(16) = 2.72, p = .015$. Analysis of Covariance (ANCOVA) was conducted with baseline goal setting values used as the covariate. The resulting analyses showed that the covariate was not significant and the results did not alter the findings based on the Mixed ANOVA.

Baseline values on self-efficacy for eating fruit 2 or more times per day (fruit self-efficacy) did not differ significantly between the manual control and GuS conditions, $t(22.7) = 1.70, p = .104$ (Table 7). Levene's test indicated unequal variances ($F = 14.22, p = .001$), resulting in a degrees of freedom adjustment from 33 to 22.7. Baseline values on self-efficacy for eating vegetables 3 or more times per day (vegetable self-efficacy) did not differ significantly between the manual control and GuS conditions, $t(33) = 1.57, p = .126$ (Table 7). A 2 (Group) x 2 (Time) Mixed ANOVA was conducted for each self-efficacy variable. Neither Group, $F(1, 33) = 2.51, p = .123$, partial $\eta^2 = .071$, nor Time, $F(1, 33) = 0.27, p = .604$, partial $\eta^2 = .008$, had a significant impact on fruit self-efficacy. The interaction (Group*Time) was not significant, $F(1, 33) = 1.01, p = .323$, partial $\eta^2 = .030$. GuS and manual control groups did not differ on fruit self-efficacy scores at Week 4, $t(33) = 0.74, p = .464$. The GuS and control groups experienced non-

significant net change of ratings of -.05 and +0.18 for fruit self-efficacy, $p > .05$. Analysis of Covariance (ANCOVA) was conducted with baseline fruit self-efficacy values used as the covariate. The results did not alter the findings based on the Mixed ANOVA.

Group, $F(1, 33) = 5.39$, $p = .027$, partial $\eta^2 = .140$, had a significant effect on vegetable self-efficacy, but Time, $F(1, 33) = 1.15$, $p = .291$, partial $\eta^2 = .034$ did not. The interaction (Group*Time) was not significant, $F(1, 33) = 0.034$, $p = .854$, partial $\eta^2 = .001$. GuS group had significantly higher vegetable self-efficacy scores at Week 4, compared to manual control, $t(33) = 2.25$, $p = .031$. GuS group had an increase in vegetable self-efficacy ratings, although this change (+0.17) was not significant, $t(17) = 1.00$, $p = .331$. The manual control group had an increase of +0.12 in vegetable self-efficacy ratings. This change was not significant, $t(16) = 0.57$, $p = .579$. Analysis of Covariance (ANCOVA) was conducted and the assumption of homogeneity of variance was met. After controlling for baseline vegetable self-efficacy values, there was only a near significant difference between groups at Week 4 on vegetable self-efficacy ratings, $F(1, 35) = 3.19$, $p = .084$.

Baseline knowledge did not differ between the GuS intervention and control groups (FET: $p = 1.0$), with a small number of participants (2 each: 11.1% and 11.8%, respectively) answering accurately how many daily servings of fruit and vegetables are recommended. Overall, accuracy increased from baseline (11.4%) to Week 4 (37.1%), with half answering accurately in the GuS intervention group post-intervention, but only 23.5% in the manual control. Excluding the four participants who demonstrated accurate knowledge at baseline, more participants in the GuS condition increased the accuracy of their knowledge than those in the manual control condition—although this was not significant, $\chi^2(1, N = 31) = 3.04$, FET: $p = .085$; OR = 4.00.

Process Outcomes: Acceptability – Program Usage and Satisfaction

Handheld computer usage data (Table 8) was able to be collected on 88.9% (16/18) of participants in the GuS condition. For these 16 participants, the average trial the GuS program ran was 29.13 days ($SD = 2.60$; range, 28-38 days). On average, data was captured for 82.8% ($N = 386/466$; $SD = 0.24$; range, 35.7% – 100%) of days in their trials. For half of the participants ($N = 8$), 100% of the days in their trial was captured, which was the modal number captured. Of days that were captured ($N = 386$), participants interacted with the program, defined as responding to at least one program-initiated prompt, on 81.1% ($N = 313$) of those days.

Table 8

Growing up Strong Program Use: Response (%) to Program-Initiated Prompts

All 6 program prompts	% daily compliance	#	% observations
	.00	73	18.9
	.17	43	11.1
	.33	39	10.1
	.50	56	14.5
	.67	71	18.4
	.83	69	17.9
	1.00	35	9.1
		Avg	50.4
Main 4 program prompts	% daily compliance	#	% observations
	.00	87	22.5
	.25	38	9.8
	.50	83	21.5
	.75	89	23.1
	1.00	89	23.1
		Avg	53.6
Compliance by Reminder Type	Reminder Type	#	% observations
	Morning reminder	152	39.4
	*First Goal Reminder	175	45.3
	*First Goal Entry Reminder	245	63.5
	*Second Goal Reminder	175	45.3
	*Second Goal Entry Reminder	232	60.1
	Evening Reminder	149	38.6

Note: $N = 386$; *Main prompt; All 6 program prompts include main prompts plus the general morning reminder and the evening goal planning reminder

Of the 6 total program prompts, 9.1% of days ($N = 35$) had perfect compliance, 45.3% ($N = 175$) had 67% compliance or better and 59.8% ($N = 231$) had 50% compliance or better. Of the 4 main program prompts (2 goal reminders and 2 goal entry), 23.1% ($N = 89$) of days had perfect compliance to the 4 main program prompts, and 46.1% ($N = 178$) had at least 75% compliance, which would qualify the participant to earn a reward for that day. Finally, 67.6% of days ($N = 261$) had at least 50% compliance to the 4 main program prompts. On average, daily compliance was 50.4% for all program prompts and 53.6% for main program prompts only.

Satisfaction with the GuS program was assessed for the participants in the GuS intervention condition through 5-point Likert-scaled self-report questions, with higher numbers indicating greater satisfaction. Most participants in GuS rated how much they liked the program ($N = 15$, $M = 4.40$, $SD = .99$); if they would recommend this program to a friend ($N = 16$, $M = 4.25$, $SD = 1.06$); and if they would do the program again ($N = 16$, $M = 4.00$, $SD = 0.97$). Sixteen of the GuS participants rank ordered the system components in order of which they liked the most (rank order 1) to the least (rank order 5). They ranked receiving music the highest ($M = 2.19$), followed by goal setting ($M = 2.44$), tips and recipes ($M = 2.75$), diary ($M = 2.88$), and receiving daily reminders ($M = 3.13$).

Exploratory sub-analyses. Additional analyses were conducted to examine whether the change in daily fruit and vegetable (FV) intake from Baseline to Week 4 was significantly different for those participants in the GuS condition who used the program more, compared to those who used it less. Usage (defined above, using all 6 program prompts) was calculated and data were coded after performing a median split (Figure 10).

The baseline FV intake was not significantly different between high and low usage groups, $t(14) = 0.98$, $p = .343$ and was not correlated to usage, $r(14) = .19$, $p = .48$. A 2x2 Mixed ANOVA was conducted. The main effect of Time was not significant, $F(1, 14) = 2.33$, $p = .149$, partial $\eta^2 = .143$, nor was the main effect of Group, $F(1, 14) = 0.09$, $p = .774$, partial $\eta^2 = .006$. The interaction (Group*Time) was not significant, $F(1, 14) = 1.14$, $p = .303$, partial $\eta^2 = .075$. Those with usage below the median increased from an average of 2.09 ($SD = 1.10$) FV servings at baseline to 3.38 ($SD = 1.84$) at Week 4. Those with usage above the median increased from an average of 2.80 ($SD = 1.73$) to 3.03 ($SD = 1.56$) FV servings. FV intake did not differ between the two usage groups at Week 4, $t(14) = 0.41$, $p = .69$.

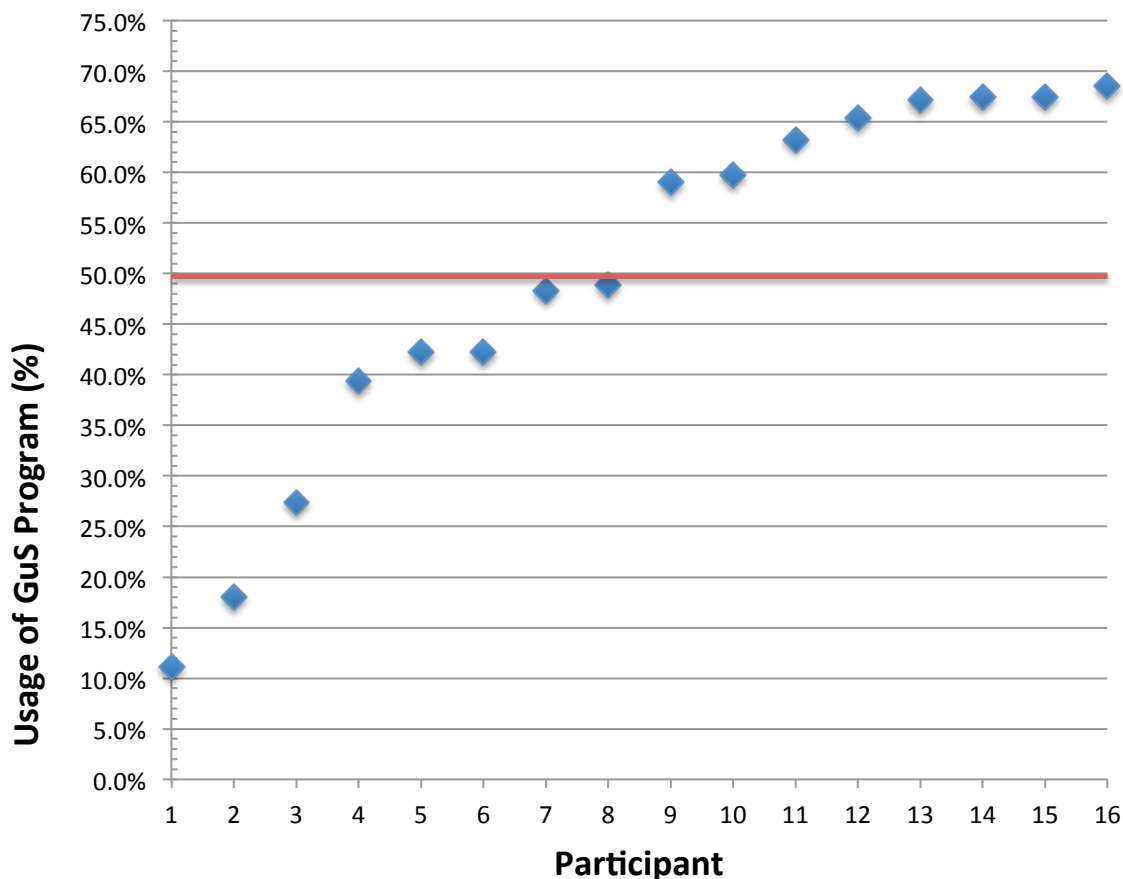


Figure 10. Growing up Strong (GuS) program usage by participant averaged across 4 weeks of the intervention. Median use (54.0%; range, 11.1-68.6%) is depicted by the red line.

Chapter 4: Discussion

To address the first aim, there was evidence that an mHealth intervention, Growing up Strong (GuS), was able to increase combined fruit and vegetable (FV) and fruit intake compared to a traditional paper-based manual control. However, the intervention did not show any impact on vegetable intake in either group. This finding is similar to other studies that have found statistically significant increases in fruit, but not vegetable intake between the intervention and control group at follow-up in pediatric populations (Perry et al., 1998; Perry et al., 2004; Te Velde et al., 2008; D. Thompson et al., 2009). However, it is different from the studies in children and adolescents that have found increases in vegetable, but not fruit intake (Baranowski et al., 2000) or a marginally significant increase in vegetable, but not fruit intake (Baranowski et al., 2002); and from others that have shown increases in both fruit and vegetable intake (Baranowski, Baranowski, Cullen, Marsh, et al., 2003; Reynolds et al., 2000).

It is not known why this intervention impacted fruit, but not vegetable intake. Many psychosocial and environmental factors could play a role including preferences for fruit over vegetables, home availability, or parent modeling (Blanchette & Brug, 2005; Granner & Evans, 2011; McClain et al., 2009). More than a third of our sample reported that they do not always have either fruit or vegetables available at home and more than one-fifth of the sample reported that their parent or parents only eat FV “1 – 2 days per week.” Furthermore, the GuS program asked participants to set a goal to add vegetables to one meal or snack and fruit to one meal or snack, but similar to guided goal setting models, they were allowed autonomy in choosing which ones (Shilts et al., 2009). Breakfast and snacks are eating episodes that are often short on FV intake in children and adolescents, making them prime targets for

intervention (Baranowski et al., 1997; Skatrud-Mickelson et al., 2011). If participants set their vegetable goals at lunch or dinner, times when FV intake is greater compared to other eating occasions, they may have not increased their intake, but consumed vegetables they would have eaten anyway. Further studies might consider varying snack and mealtime options to optimize FV intake increases.

Although the ANOVA Group*Time interaction was not significant for total FV intake, the ANCOVA revealed that after controlling for baseline levels, the GuS group had significantly higher FV intake at Week 4 compared to the control group. The GuS group showed a +0.91 change in FV intake, resulting in a large effect (partial $\eta^2 = .143$). This increase was solely attributed to the +0.97 change in fruit intake in the GuS group from Baseline to Week 4. This increase in FV intake is on the higher end of that which is reported in the literature for community-based interventions (0.3 – 1.0), especially in pediatric populations (Ammerman et al., 2002; Knai et al., 2006; Thomson & Ravia, 2011). It is right in line with other eHealth pediatric FV interventions, such as *Squire's Quest!* multimedia game, which reported a +0.91 increase in FV (Baranowski, Baranowski, Cullen, Marsh, et al., 2003) and *Food, Fun and Fitness* Internet program, which boasted a +1.0 increase (D. Thompson et al., 2008).

This study's FV intake increase was lower than the +1.77 increase found in our development pilot data (Nollen et al., 2012). This might be explained by FV intake assessment methods. The current study used 24-hour recalls, which are less prone to social desirability bias. Our development pilot utilized a 2-item screener. Although the screener shows good correlation with 24-hour recall data, the girls in the development pilot would likely be more invested in the program doing well because they helped develop the program, and therefore

more prone to bias. The difference could also be explained due to the length of the intervention period. The current study had a longer intervention period compared to the development pilot, and intervention effects are often more pronounced early in the intervention and wane over time. Although not as high as the development pilot, this study's +0.91 FV change was a substantial increase. For example, if this serving replaced foods with greater caloric density and could be maintained over time, this change is significant enough to address the energy imbalance in pediatric populations (Y. C. Wang et al., 2012). However, from a nutritional standpoint, this increase was not enough to bring participants up to even minimum recommended amounts (post intervention = 3.22 FV servings per day). Although the low baseline FV intake that we found is common in African American female youth (Klesges et al., 2010; D. Thompson et al., 2008), it supports the need for continued efforts at creating and implementing comprehensive interventions in this high-risk population.

Similar to other pediatric FV interventions, treatment gains were not maintained over time (Ammerman et al., 2002; T. A. Nicklas et al., 1998; Reynolds et al., 2000; D. Thompson et al., 2009). This again indicates the need to create avenues for children and teens to engage in longer-term behavior change skills. This could potentially be achieved by incorporating intermittent intervention booster sessions over a longer period of time. There is also the potential of using mHealth modalities over extended continuous periods of time (e.g., 6 months – 1 year) with multiple assessments. However, the current study was not equipped to address these issues due to concerns of participant burden and resource limitations. These could be explored in future studies.

There was evidence that the GuS program impacted behavior change skills from Baseline to Week 4 Follow-up. GuS helped participants achieve a significant increase in number of days tracking their FV intake (+2.0 days/past 7), which was not experienced in the control condition, indicating the program facilitated greater dietary self-monitoring. The ANOVA Time main effect was significant for goal setting and post hoc analyses showed a near significant increase in days spent making an effort to increase FV for the GuS group and a significant increase in the manual control group. Although this increase was not expected in the control group, the paper manual that was utilized had areas (i.e., worksheets) where participants were asked to set goals to increase FV intake. While both groups reported an increase in number of days engaged in trying to improve FV intake, only the GuS group was successful. This could be contributed to a number of factors. The real-time reminders, goal planning module, real-time tips and strategies, and overcoming barriers module could all work toward aiding successful dietary behavior change.

The intervention did not seem to significantly impact fruit self-efficacy ratings, but one difference did emerge, with GuS participants having higher vegetable self-efficacy ratings at Week 4, compared to the control condition. These findings highlight that increases in self-efficacy do not necessarily translate into behavior change. Finally, knowledge of FV recommendations increased more in the GuS compared to manual control group, although this finding was only near significant ($p = .085$).

Several strengths and limitations of the study must be considered. As aforementioned, although this study was not equipped to indicate long-term usage patterns and the sustainability of the program over longer periods of time, the 4-week usage data and process

outcome evaluation results were promising. Participants rated the program highly and maintained good usage. Of the data that was captured, most days in the combined trials showed program use at least once throughout the day (81.1%). On average, compliance was 50.4% for all program prompts and 53.6% for the main program prompts, which consisted of the two real-time reminders and the two real-time goal assessment and feedback prompts. This is lower than the 78.3% compliance found in the development pilot (Nollen et al., 2012). The daily compliance (81.1%) was also slightly lower than adherence rates (94%) found in a handheld computer trial of children required to complete daily pain diary assessments (Palermo et al., 2004). Both the development pilot and pain diary study intervention periods were shorter in duration (1 – 2 weeks) than the current study. This could explain why the present study had lower adherence rates—because compliance might tend to decrease over time.

It is difficult to determine what aspects of the program related to the changes that were found in the GuS group. Furthermore, because we did not measure use of the paper manual, it is not clear how the intervention components were related to changes seen in goal setting. It is unknown how well the study results would generalize to those outside the population of interest, that is, low-income, predominantly African American girls. Furthermore, we have no data on the girls who did not choose to participate compared to those who did. Incentives were provided to Growing up Strong program participants for responding to prompts regardless of whether or not they were able to meet their fruit or vegetable goals. Because of the use of incentives, generalizability may be further limited to other programs that would also be able to provide incentives. This broaches the issue of costs related to this study and real-world applicability. Other costs limitations that must be considered are the costs of purchasing and

maintaining mobile devices, as well as the costs of developing and purchasing mHealth apps. Cost analysis was beyond the scope of this project. However, one important potentiality of mobile technologies is the ability to increase the reach of interventions and there is evidence that ownership of mobile technologies and use of them, at least among teens, is increasing.

The PDA device used in this study is now outdated technology and only runs on the Windows Mobile OS. However, the GuS program was designed to test features of mobile technologies, such as the ability to provide cues to action (Nollen et al., 2012), and therefore informs the development of similar health promotion programs or mHealth apps for various mobile operating systems or modern devices (e.g., smartphones, Wi-fi devices, such as IPOD touch, and other cellular or Wi-Fi products, such as Tablet PCs or IPAD).

Future directions of study might consider varying system components (e.g., incentives) to understand how different components impact effectiveness and program usage, running longer trials to gauge the longevity of programs, or using control groups addressing other health behaviors. Unfortunately, some of these study designs involving programmatic changes might be cost-prohibitive, but all are gaps in our knowledge about how these programs may operate to effect behavior change. The mHealth field is ripe for development. There is also a need to develop a similar, but gender-tailored program for high-risk boys.

This study was part of a larger randomized trial. Currently, analysis is underway to determine the effect of the modules addressing sugar-sweetened beverage consumption and screen time activities in promoting behavior change and whether these two modules, combined with the FV module, had an impact on BMI outcomes. The benefit of creating app modules is that they can be mixed and matched depending on the needs of the individual.

Healthcare providers and pharmaceutical companies are projected to be some of the largest developers and consumers of future programs. The draw for healthcare providers is the ability of using apps for patients to manage chronic health conditions (e.g., diabetes, obesity).

Programs like GuS could be added to other multi-component interventions, as eHealth additions in previous FV trials (Baranowski, Baranowski, Cullen, Thompson, et al., 2003; D. Thompson et al., 2009). Based on models of multiple health behavior change (Prochaska & Prochaska, 2011), a FV program like GuS could represent the FV portion of a larger intervention or could reinforce other FV intervention material. From its versatility, potential to extend the reach of interventions to underserved, at-risk populations, and the preliminary findings of its effectiveness, GuS appears to be a powerful tool for impacting health behavior change and modifying dietary habits among children and adolescents.

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Appendix A: Participant Flow Diagram – Primary Outcome

